OFFICE OF THE LORD PRIVY SEAL

SECTIONAL STEEL SHELTERS

REPORT

UPON

INVESTIGATIONS OF THE STANDARD OF PROTECTION AFFORDED

PROOF TESTS OF ANDERSON SHELTER

Presented by the Lord Privy Seal to Parliament
by Command of His Majesty
July, 1939

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REPORT.

INTRODUCTORY.

In a statement made on behalf of the Government on air raid shelters in the House of Commons on 21st December, 1938, the Lord Privy Seal announced that it was a part of the policy that the protection for the ordinary citizen should be arranged in or close to his own house.

Ways and means for giving effect to such policy had already been under special consideration and the outline of a design had been recommended by a panel of Consulting Engineers.* The essential features of the design were that the shelter could take four to six persons, provide the standard protection against air attack short of a direct hit, be capable of rapid mass production, be easy to store, pack and transport, and not difficult to erect. Moreover, the suggested shelter was compact, durable, required little or no upkeep and compared favourably in prime cost with other designs.

War time experience of the " elephant " type of metal shelter had suggested the form the design might take, and with the valuable help of the British Steelwork Association every item was minutely examined from the aspect of ease and economy in production. Test models were produced on the basis of a sectional arch using galvanised corrugated mild steel sheets of heavy gauge.

PHYSICAL TESTS.

(a) *Dropping load, and dead load tests.*

The next step was to subject these models to physical load tests at the works. It was found that 14 gauge mild steel with 5 inch corrugations about $1\frac{1}{8}$ inches deep, provided a sheet which, when curved to a radius of 2 feet 3 inches, formed a remarkably strong and simple cover.

Loads of bricks and stone of from $1\frac{1}{4}$ to 2 tons were dropped from heights up to 25 feet on to the trial shelters without any earth covering, while in a dead weight test a load of 75 tons of pig-iron was piled over the bare shelter. In neither case was there sign of failure.

These works tests gave enough prima-facie evidence of the strength of the design to warrant carrying the tests to a more crucial stage.

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* Mr. David Anderson, LL.D., B.Sc., M.Inst.C.E., Mr. B. L. Hurst, M.Inst.C.E., Sir Henry Japp, K.B.E., M.Inst.C.E.

(b) *Explosion tests.*

By this time the design was to all practical purposes identical with the illustrations contained in the " Directions for the erection and sinking of the galvanised corrugated steel shelter " issued in February, 1939. It will be realised that the shelter is in essentials a steel hood, covered by earth, partly sunk in the ground and resting on a steel framework. It has an entrance and an emergency exit. For resistance to crushing by debris from damaged buildings the shelter depends firstly upon the earth covering to distribute the blow and secondly upon the strength of the steel hood. The steel framework prevents the hood from being driven down into the ground or shifting sideways. The earth covering also constitutes the protection from bomb and anti-aircraft shell fragments, machine-gun bullets, and the light incendiary bomb. The mere fact that the shelter provides an enclosure affords a protection against blast, and this is helped by the sinking of the shelter in the ground, which incidentally reduces the area, and particularly the height of exposure to lateral attack by bomb fragments.

The explosion tests, about to be described, were designed to discover to what extent the shelter gave protection against splinters and blast from high explosive bombs. Both these tests and those described later were supervised by the Superintendent of Experiments, Shoeburyness, under the auspices of the Ordnance Board.

After a preliminary trial with one shelter, tests were so arranged that they included the following variations in conditions:—

Distance of shelter from the bomb—50, 25, 15 and 10 feet—four shelters at each distance.

Depth of floor of shelter below ground surface—3 feet and 1 foot—eight shelters at each depth.

Position of bomb—(i) with nose touching the ground surface; (ii) with nose sunk 4 feet below the ground surface.

Position of shelter with reference to bomb—Twelve shelters broadside on, and four shelters with the closed end (i.e. emergency exit end) towards the bomb.

Suitably to present every important combination of circumstance, it was necessary to use 16 separate shelters. Diagrams A to C illustrate the disposition of the shelters. In each variation a sandbag screen wall was built 4 feet from the entrance to the shelter to represent the protection afforded by the house or cottage opposite which the shelter should in practice be placed. The top of the screen wall was made level with the top of the earth covering over the shelter.

In all, three 500 lb. bombs were used, the shelters being disposed round the bomb at the required distances in groups of four, four and eight respectively.

Over each shelter earth was piled and rammed to give a cover 1 foot thick on the top of the shelter and was sloped outwards so that at ground level the thickness was 3 feet. The thickness at ground level was increased to 4 feet 3 inches for one shelter at 15 feet from the bomb (No. 3, Diagram " A ") and for another shelter at 25 feet from the bomb (No. 2, Diagram " A "). The general intention is that the shelter should have a minimum cover of 15 inches on the top, so that the conclusions to be drawn from the generality of the tests apply with greater force to shelters covered to the full standard thickness.

Before describing the effect of the explosion on the shelters it is important to observe what happened to the ground where the bomb had been placed. The ground is a sandy loam and sub-soil water is met at a depth of from 1 to 3 feet according to the season.

The effect of the explosion, with the bomb at ground surface, was to score in the ground a circular wide mouthed pit, or crater, about 16 feet wide and 3 feet deep, and one about twice as wide and three times as deep when the bomb was sunk 4 feet in the ground.

Diagram	Depth of nose of bomb	Diameter of crater	Depth of crater	Date of trial
		Feet.	Feet.	
"A" & "B"	Nose of bomb touching the ground.	16	3	23.1.39
" C "	Nose of bomb sunk 4 feet in the ground.	30	9½	23.1.39

Some idea of the force of the explosion can be gathered when it is calculated that the weight of earth blown into the air (Diagram " C ") was about 110 tons.

The effect of the explosions on the shelters was as follows:—

At a distance of 10 feet from the bomb all four shelters within that range were wrecked, whether the bomb was on the surface or sunk, and whether the floor of the shelter was 3 feet or only 1 foot below the ground surface. An explosion occurring at a distance of about 10 feet must be taken as equivalent to a direct hit. At a distance of 15 feet all the shelters were wrecked by the bomb sunk 4 feet in the ground, but in the case of the surface bomb the shelters were only slightly damaged at the end nearest the bomb and perforated by fragments near the top. At 25 feet, with the sunk bomb, no damage occurred to any

shelter except some slight displacement of earth. At 25 feet, with the bomb on the surface, no damage occurred to shelters sunk 3 feet in the ground except slight disturbance of earth covering. One of the shelters sunk 1 foot in the ground was slightly crushed at the side nearest to the bomb and perforated by three fragments at heights of 4-5 feet above floor level. At 50 feet there was no damage except for some disturbance of the earth covering on near side.

Hence these full scale explosion trials have shown that at a distance of 50 feet the fabric of the shelter is not damaged by the explosion of a 500 lb. medium case bomb whether the bomb explodes at the ground surface or sunk to a depth of 4 feet below the surface, and whether the shelter floor is 1 foot or 3 feet below the ground.

In addition to this series of tests a demonstration was given before representatives of the Press in which two shelters were exposed not only to blast and bomb fragments from a 500 lb. bomb but also to the collapse of a brick building alongside. The shelters were 36 feet from the bomb, and were placed broadside on, and they were 6 feet from brick buildings representing a house. The nose of the bomb was sunk 18 inches into the ground. After the explosion of the bomb it was seen that no damage whatever was caused to the shelter itself, although small portions of the earth covering the steel structure were disturbed.

PHYSIOLOGICAL CONSIDERATIONS AND TESTS.

The explosion tests have shown that, apart from disturbance of the earth covering, the fabric of the shelter, if installed as recommended, is not injured by blast from the explosion of a 500 lb. bomb bursting even as close as 25 feet. The important question which will now be dealt with is that of the effect of blast* on persons within the shelter.

This has been tackled from two separate directions, by instrumental measurement of pressures inside and outside the shelters, and by direct experiment on animals.

Sensitive instruments have recently been introduced which record on a photographic film by means of an electrically operated mechanism the variation in the intensity of the blast pressure wave as it passes. These pressure-time curves, so obtained, have made it possible to analyse the blast effects with a considerable degree of precision. In the Table below the figures are collected of measurements recorded by these means. In conjunction with this Table reference is made to Diagram

* The characteristics of blast are described in A.R.P. Handbook No. 5, "Structural Defence," Chapter II.

" D " which shows the position of the shelters mentioned by letter. It may be noticed that, while some of the shelters were placed behind other shelters, this alignment would, in the case of blast, confer no protection.

These measurements would only have relative value unless it were known what pressure could be safely borne by human beings. Fortunately it is known from other service experience that a pressure up to 5 lb. per square inch is safe. From the Table it will be seen that in the open air outside a shelter at a distance of 30 feet from a 500 lb. medium case bomb exploding on the ground surface the pressure is about 20 to 24 lb. per square inch, but inside a shelter whether the door is closed or open and whether the shelter is placed end on or sideways on to the bomb the pressure is less than 5 lb. per square inch. At 50 feet the pressure in the open is about 6 lb. per square inch and inside shelters in the same relative positions it is 1 lb. per square inch or less.

It is considered that these pressure measurements afford reliable evidence of the protective value of the shelter against blast pressure, and show that persons within shelters placed, in accordance with the directions, so that the entrance is facing a house or a screen wall can safely be exposed to the blast from a 500 lb. medium case bomb bursting in the open on the ground surface, or below it, at a distance of, or exceeding, 30 feet.

BLAST PRESSURES INSIDE AND OUTSIDE SHELTERS.

Position	Distance from Bomb	Maximum Pressure
	Feet.	lb./sq. in.
In open, outside shelters M.C.J.G.	15	Probably about 50
Inside shelter J, side on to bomb, door open	15	12–16
Inside shelter G, end on to bomb, door open	15	7
Inside shelter C, side on to bomb, door closed	15	6
Inside shelter M, end on to bomb, door closed	15	4
Outside shelters B, E, H, L, in open	30	20–24
Inside shelter L, side on to bomb, door open	30	4½
Inside shelter B, end on to bomb, door open	30	3
Inside shelter E, side on to bomb, door closed	30	2
Inside shelter H, end on to bomb, door closed	30	1½
In open, outside shelters A.D.F.K.	50	6
Inside shelters, A.D.F.K.	50	0–1

With the object of obtaining direct evidence of the physiological effects of blast an experiment was carried out on 27th

April, 1939, under the supervision of Sir Joseph Barcroft* and with the co-operation of officers of the Chemical Defence Research Department, the Medical Research Council, and the Royal Army Medical Corps.—Goats and rats were exposed to the blast from the bursting of a 500 lb. medium case bomb, placed vertically with its nose resting on the surface of the ground. Some of the animals were in the open, others were in the shelters. The shelters were arranged in three rings, 15 feet, 30 feet, and 50 feet respectively, as shown in Diagram "D". Two goats were tethered inside each shelter standing on floor boards, and one goat was tethered outside the shelter standing in a trench about 1 foot deep.† Six rats were placed inside each shelter in cages which were raised on sandbags about a foot above the floor-boards. Three rats were placed outside each shelter, raised about a foot above the ground on sandbags.

The findings have been summarised as follows:—

Inner ring goats.

Four outside the shelters.—All showed injury to the lungs, the lesions being more consistent with sudden distension of the lungs with air than external pressure on the ribs.

Eight inside the shelters.—Seven goats showed no abnormality; the muscles of one shoulder of one goat were bruised, due possibly to the end of the shelter having been slightly blown in against the animal.

It thus appears that the goats situated outside in the inner ring suffered damage to the lungs, presumably due to blast. No damage, apart from the bruise mentioned, occurred to any goat within a shelter.

Middle ring goats.

No damage appears to have been done to the 12 goats either outside or inside at 30 feet from the explosion.

Outer ring goats.

Four outside the shelters.—Three goats were normal. In one goat evidence of old‡ intrapulmonary haemorrhage was found, but it was slight in degree.

Eight inside the shelters.—Seven goats were normal. In one goat the remnants of old‡ small intra-alveolar haemorrhage were found.

Inner ring rats.

Outside the shelters the rats suffered considerable damage. This may be the result of the collapse of sandbags on the animals.

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* Professor Sir Joseph Barcroft, C.B.E., D.Sc., F.R.S.

† The goats tethered outside the shelters on the 50 feet circle were standing on the ground surface.

‡ The adjective "old", as opposed to "fresh", is used to indicate a condition which does not appear to owe its existence to the experiment.

Inside the shelters the rats showed no ill effects, nor suffered any lesions, with the exception of one rat which was not killed for post-mortem examination until 15th May, when evidence was found of fresh* intra-alveolar haemorrhage. No explanation for the findings in this rat is readily available.

Middle ring rats.

None showed abnormality, except one which had traces of an old* haemorrhage.

Outer ring rats.

Outside the shelters.—Two rats only showed signs indicative of pulmonary haemorrhage when killed on 15th May for post-mortem examination.

Inside the shelters.—One rat only showed any damage and that not severe, to the lungs.

GENERAL CONCLUSIONS.

A.—Animals situated outside the shelters, in the inner ring 15 feet from the 500 lb. bomb, received the greatest damage. The lesions were situated in the lungs and their character suggested trauma following sudden distension of the lung. Animals outside the shelters, in the middle and outer rings 30 feet and 50 feet respectively from the bomb suffered relatively little; again the damage was pulmonary.

B.—It is noteworthy that little damage occurred to animals situated within the shelters in any of the three rings. Of the 24 goats exposed in the shelters not one suffered from blast. Of the 72 rats the lungs of two only showed lung lesions—the cause of these was in doubt.

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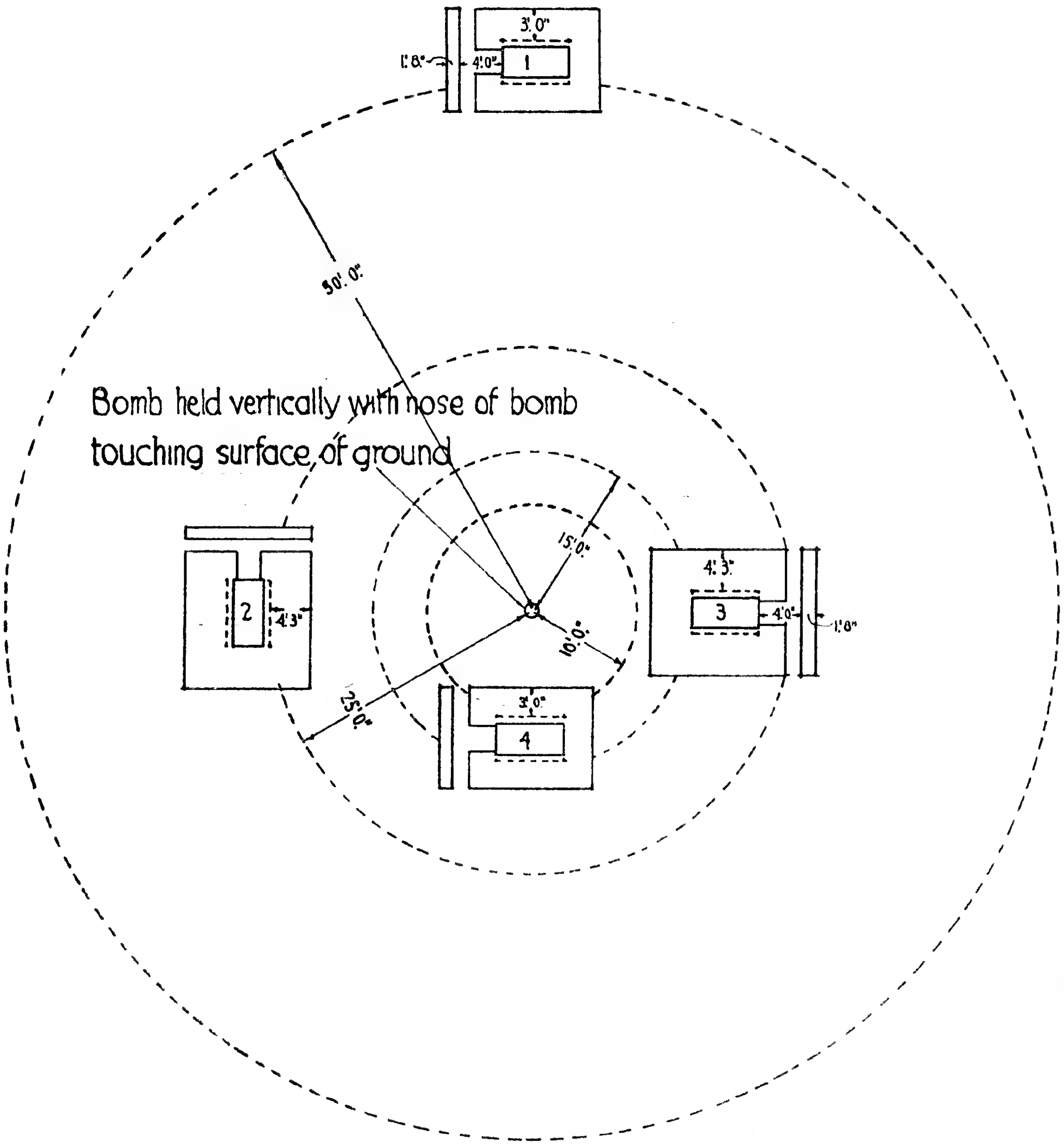
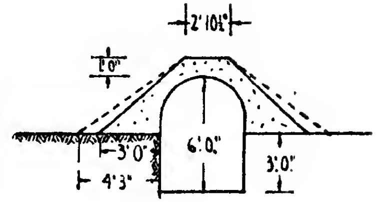
* The adjective "old", as opposed to "fresh", is used to indicate a condition which does not appear to owe its existence to the experiment.





TESTS MADE ON 23. 1. 39.

Scale of feet.

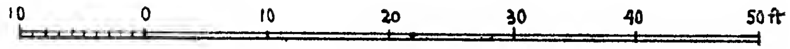
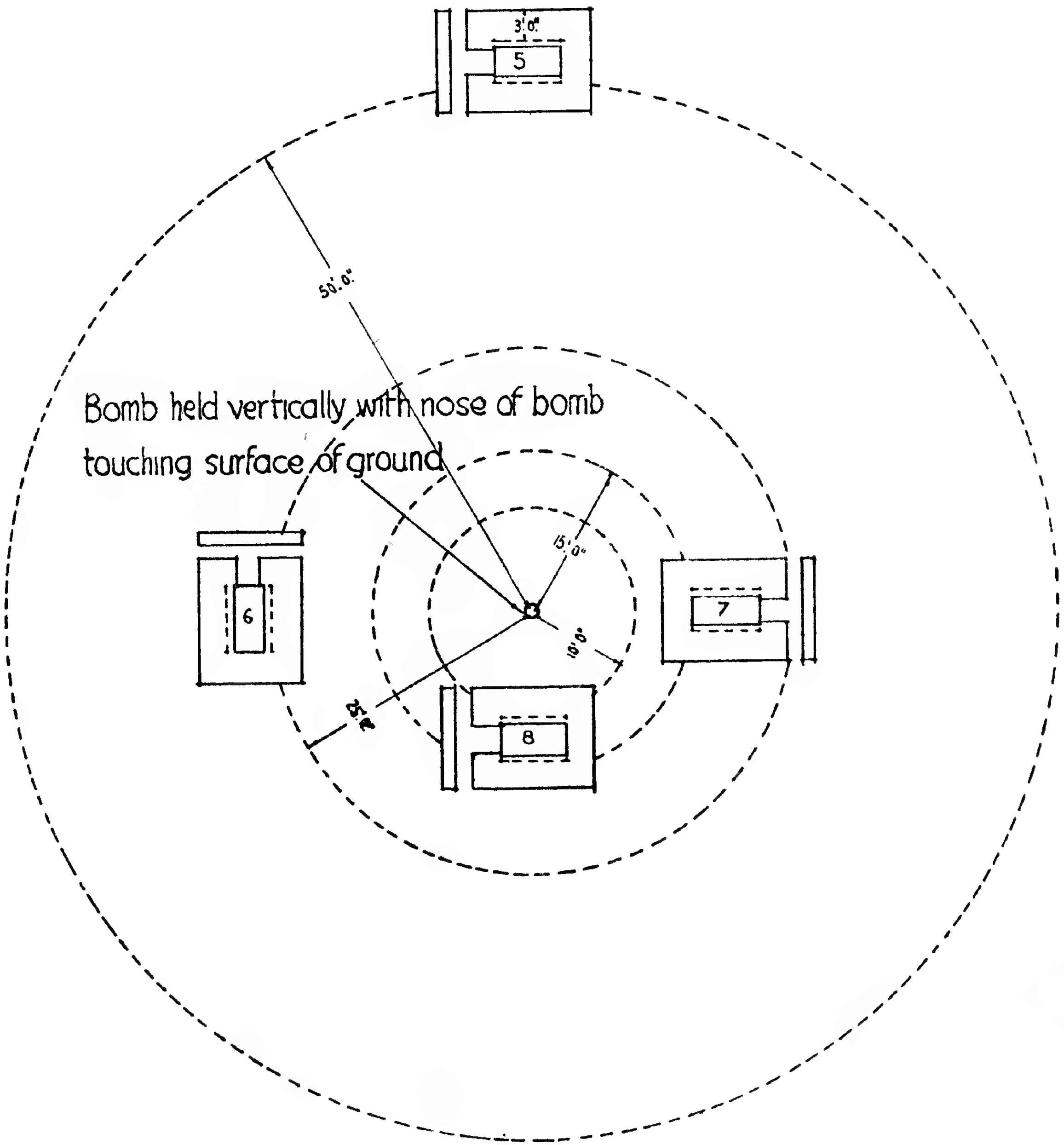
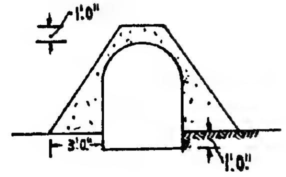


Diagram "A"





TESTS MADE ON 23.1.39.

Scale of feet

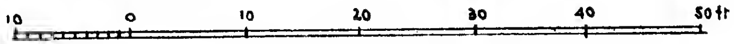


Diagram "B"

A.R.P.

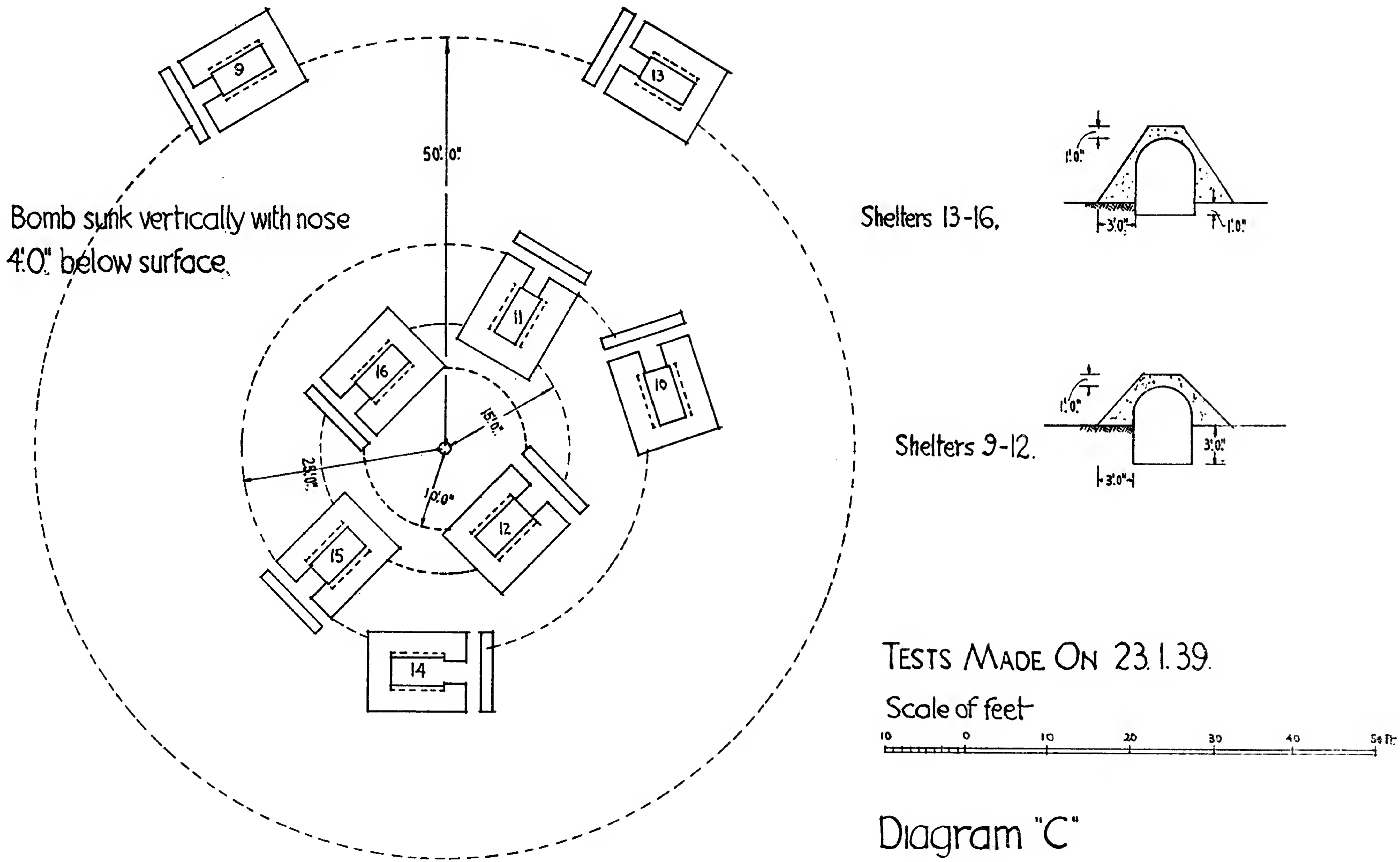
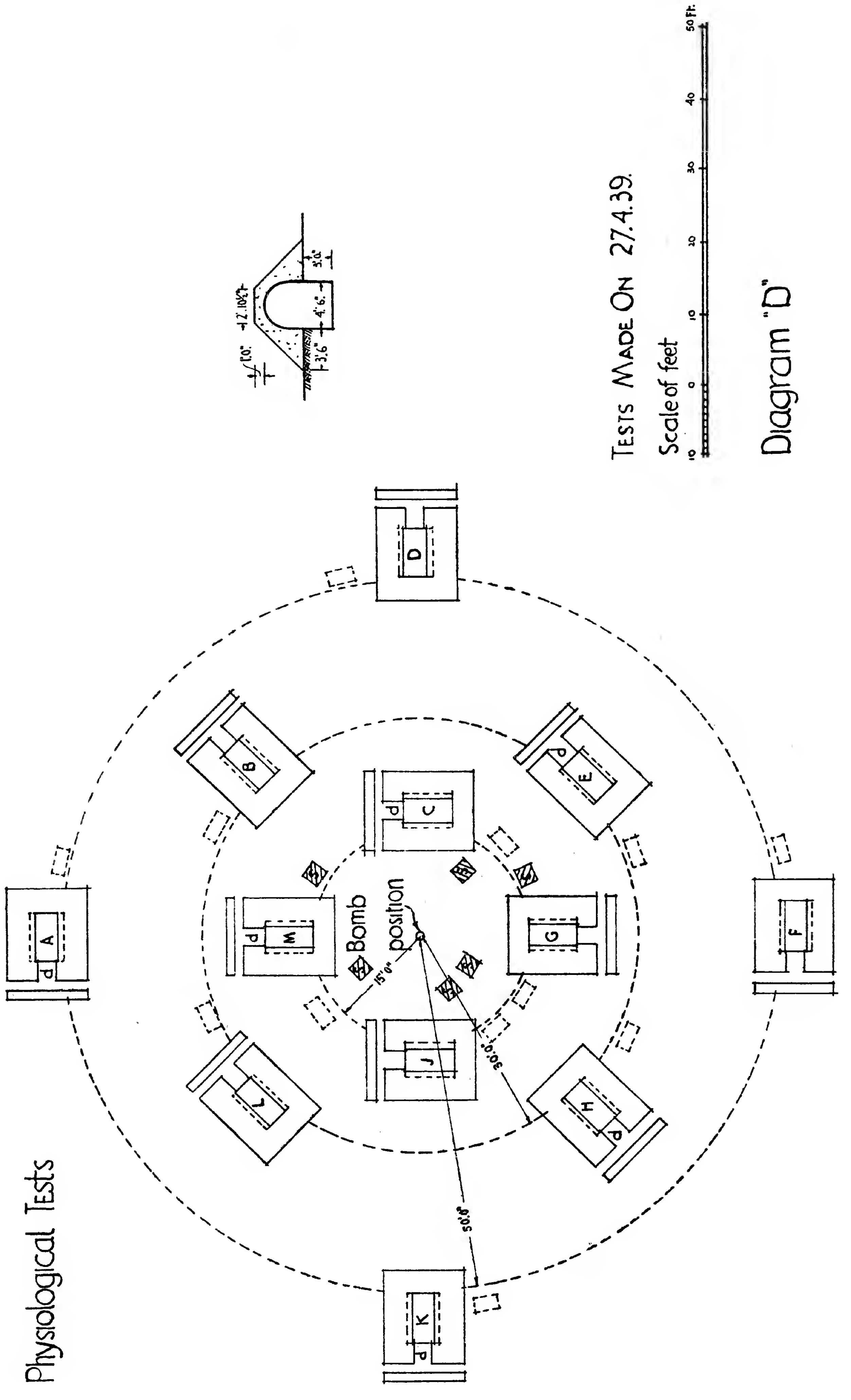

Bomb sunk vertically with nose
4'0" below surface.
50' 0"
25' 0"
15' 0"
10' 0"
9
10
11
12
13
14
15
16
Shelters 13-16.
1' 0"
3' 0"
1' 0"
Shelters 9-12.
1' 0"
3' 0"
3' 0"
Tests Made On 23.1.39.
Scale of feet
10
0
10
20
30
40
50 Ft.

Diagram "C"



(18746) Wt. 695—146 7,040 7/39 P. St. G. 373

SHELTER POLICY.

HC Deb 20 April 1939 vol 346 cc471-6

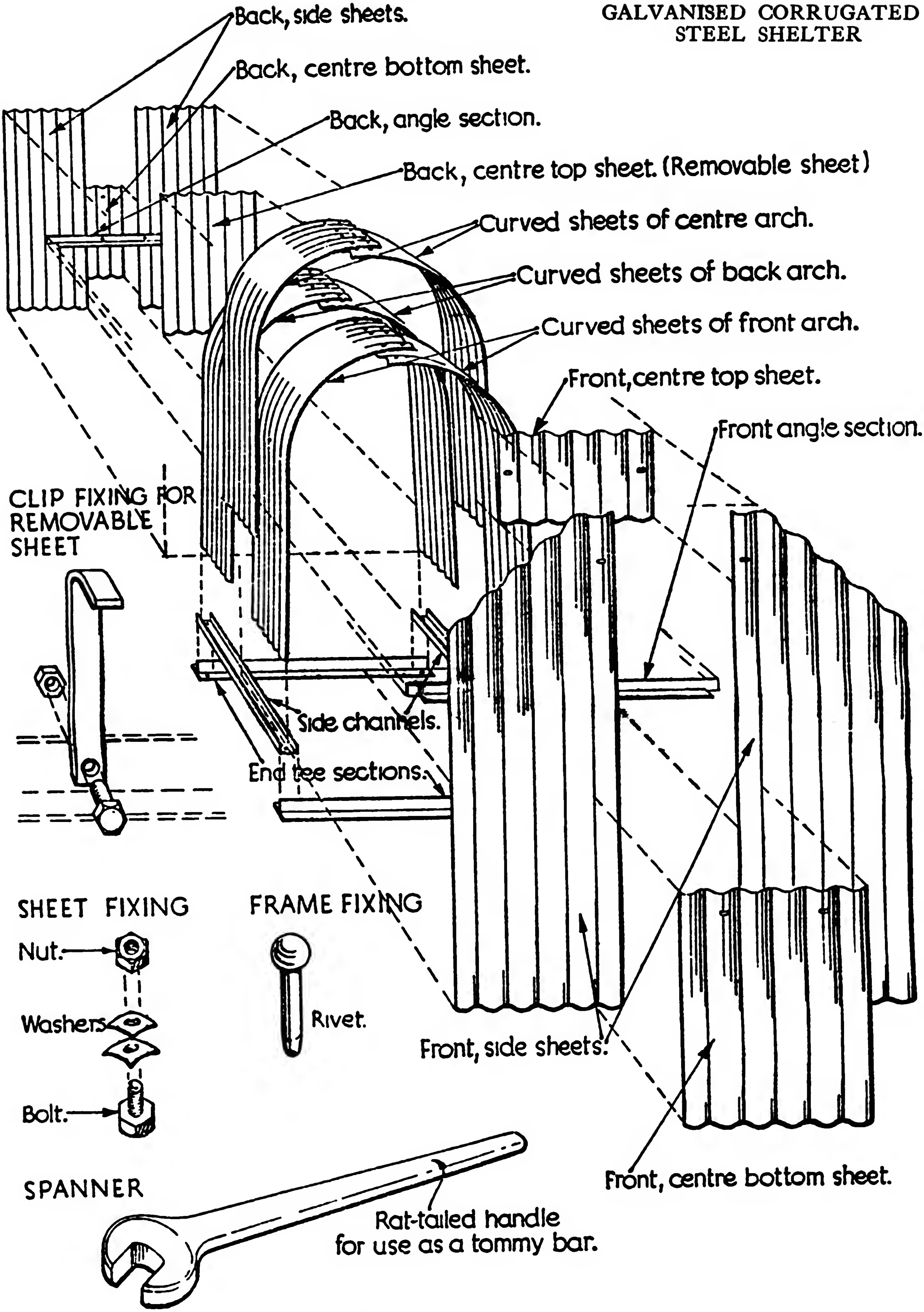
65. *Mr. Graham White* asked the Lord Privy Seal whether he is in a position to make any further statement with regard to the policy of His Majesty's Government in relation to deep air-raid shelters?

70. *Mr. Noel-Baker* asked the Lord Privy Seal whether he can now make a statement concerning the policy he proposes to adopt for providing deep shelter for the population of vulnerable areas?

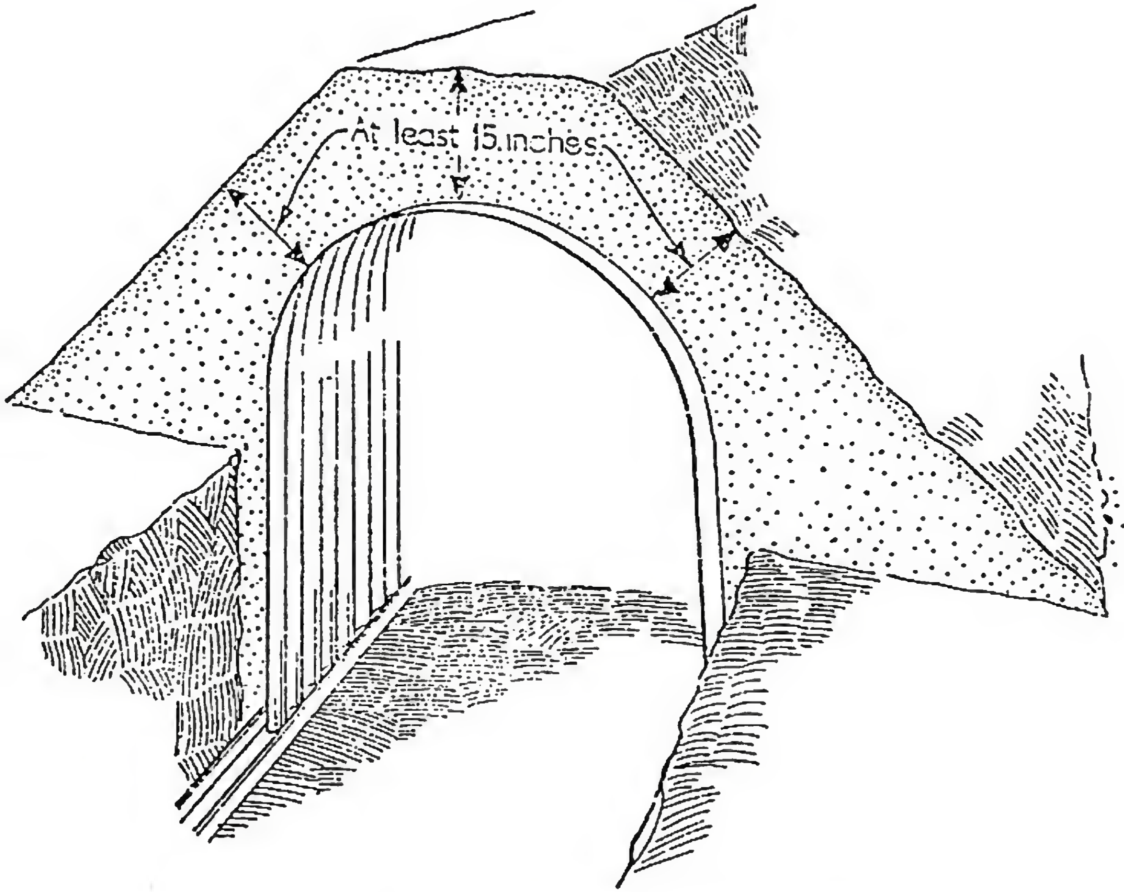
Sir J. Anderson The Government are now in a position to announce their policy in regard to the provision of heavily protected shelters against air attack; but, before stating the conclusions arrived at, I should like to summarise the various stages in the development of the Government's shelter policy so that the matter may be viewed as a whole and in proper perspective.

The House may recollect that on 3rd November last my right hon. Friend the Home Secretary indicated that it would be the policy of the Government to provide protection against splinter, blast and the fall of debris for all in vulnerable areas who could not fairly be expected to provide it for themselves. A fortnight later, after certain preliminary work had been carried out Departmentally, I called to my aid in settling the details of this policy three engineers of great eminence recommended for this purpose at my request by the President of the Institution of Civil Engineers. These engineers, working in conjunction with the technical advisers of my Department, presented their report on 20th December; and before the House rose for the Christmas Recess I made a detailed statement of the means by which effect was to be given to that policy and of the special Exchequer assistance to be made available.

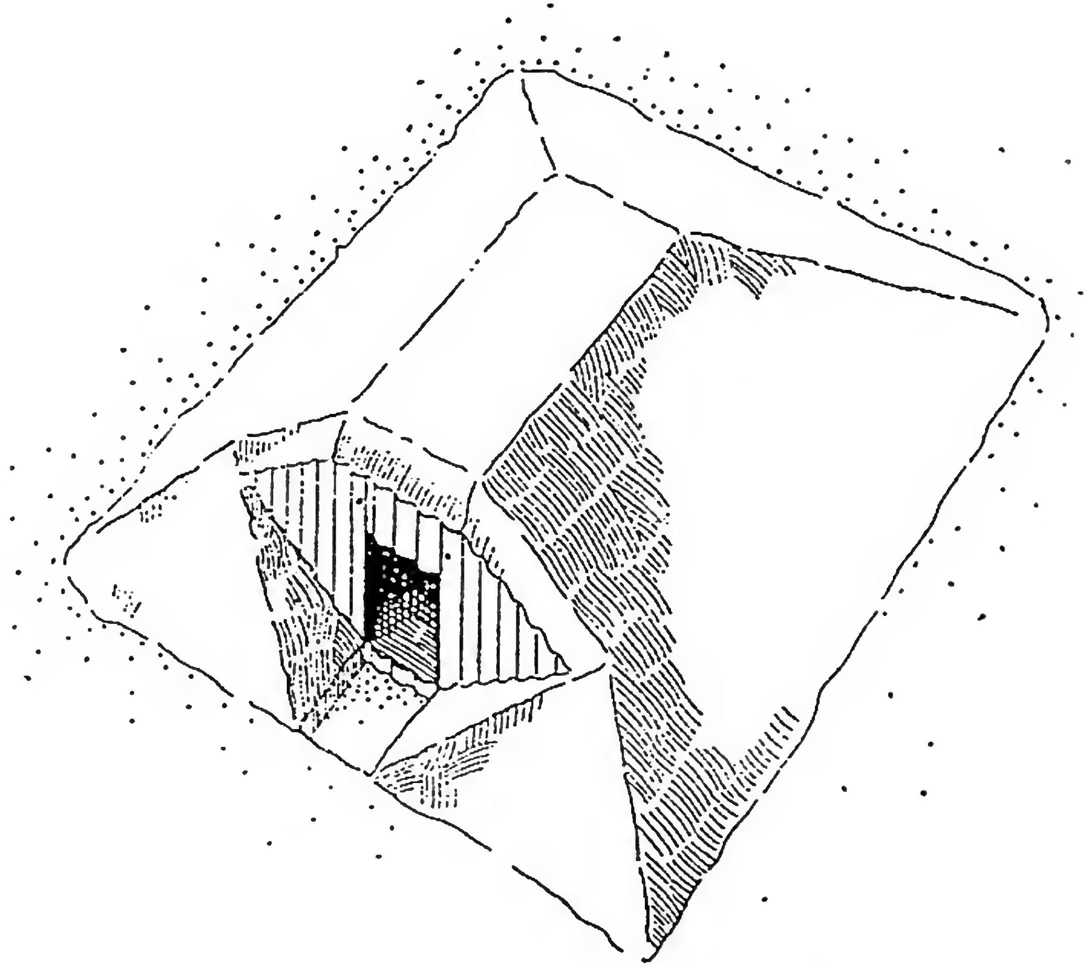
It will be recalled that the policy involved the adoption of a variety of expedients according to the varying conditions under which protection had to be provided. As the House knows, the first item in that policy comprised the distribution on a very large scale of a simple type of portable steel shelter suitable for erection in the gardens or yards of two-storey dwelling-houses. The distribution of these shelters began on the 20th February and has proceeded at a rate substantially in excess of the estimates originally made by the engineers. Already over 300,000 unit shelters capable of sheltering up to 1,500,000 people have been distributed; and distribution will for the future proceed at an accelerated rate.



ANDERSON SHELTER



Covering the Shelter with Earth.

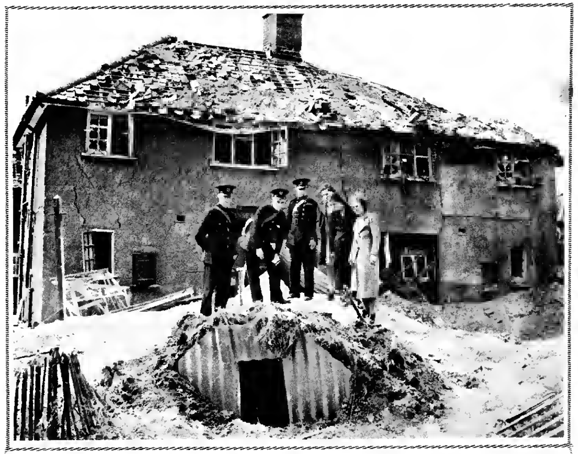


The Shelter Complete with Earth Cover.

Anderson shelter destroyed by absorbing the blast in 1940 London protected five shelterers from injury

AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS: ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

AN ANDERSON SHELTER, CORRECTLY COVERED WITH EARTH (FROM WHICH CABBAGES SPROUT), UNHARMED DESPITE SURROUNDING BOMB DAMAGE. *Wide World.*



DAMAGED HOUSES, WITH AN UNTOUCHED ANDERSON SHELTER IN THE FOREGROUND, WHOSE OCCUPANTS FOUND COMPLETE SAFETY. *(Planet.)*

INTACT AMONG THE DÉBRIS CAUSED BY GERMAN BOMBS: AN ANDERSON SHELTER IN A S.-W. LONDON SUBURB. *(Planet.)*

TWO ANDERSON SHELTERS IN THE SAME DISTRICT AS THAT SHOWN IN THE PHOTOGRAPH ON THE LEFT, ALSO INTACT. *(Planet.)*

A LARGE BOMB-CRATER BEHIND A ROW OF DAMAGED HOUSES AFTER THE CROYDON RAID: THE SHELTERS WERE UNAFFECTED. *(Keystone.)*

THE violent and very expensive raids by the *Luftwaffe* in the week ending August 17 provided a most reassuring demonstration of the efficacy of the Anderson shelter, when it has been properly covered with earth and the entrance adequately screened. Both at Croydon and in the Midlands its value was proved. When a bomb dropped in the middle of a triangle formed of three Anderson shelters in a Midlands town the occupants of all escaped unhurt. Seven people taking cover in a home-made shelter, however, were killed. Seven persons sheltering in an Anderson shelter in another Midlands area were unharmed by a bomb which exploded immediately outside it. When sixteen Nazi bombers were caught at Tilbury (Essex) between the A.-A. barrage and "Spitfires," they scattered and fled to sea with a vicious pursuit encouraging them. Six of their bombs fell on a housing estate. Four exploded harmlessly on grass verges, and two blew out the sides of a council house, but the occupants were in their Anderson shelter, less than ten yards away, and were unhurt. One man in South London, with his wife and two children, who had been evacuated from Folkestone, said that they were in an Anderson shelter during the raid on August 18 when five bombs fell within a distance of 100 yards. "Our little shelter trembled," he said, "but we suffered no shock and no damage, though our windows were broken." On the other hand, people in an Anderson shelter in the South-Western suburbs were injured by bomb splinters penetrating the back of the shelter, which was not completely covered with earth.

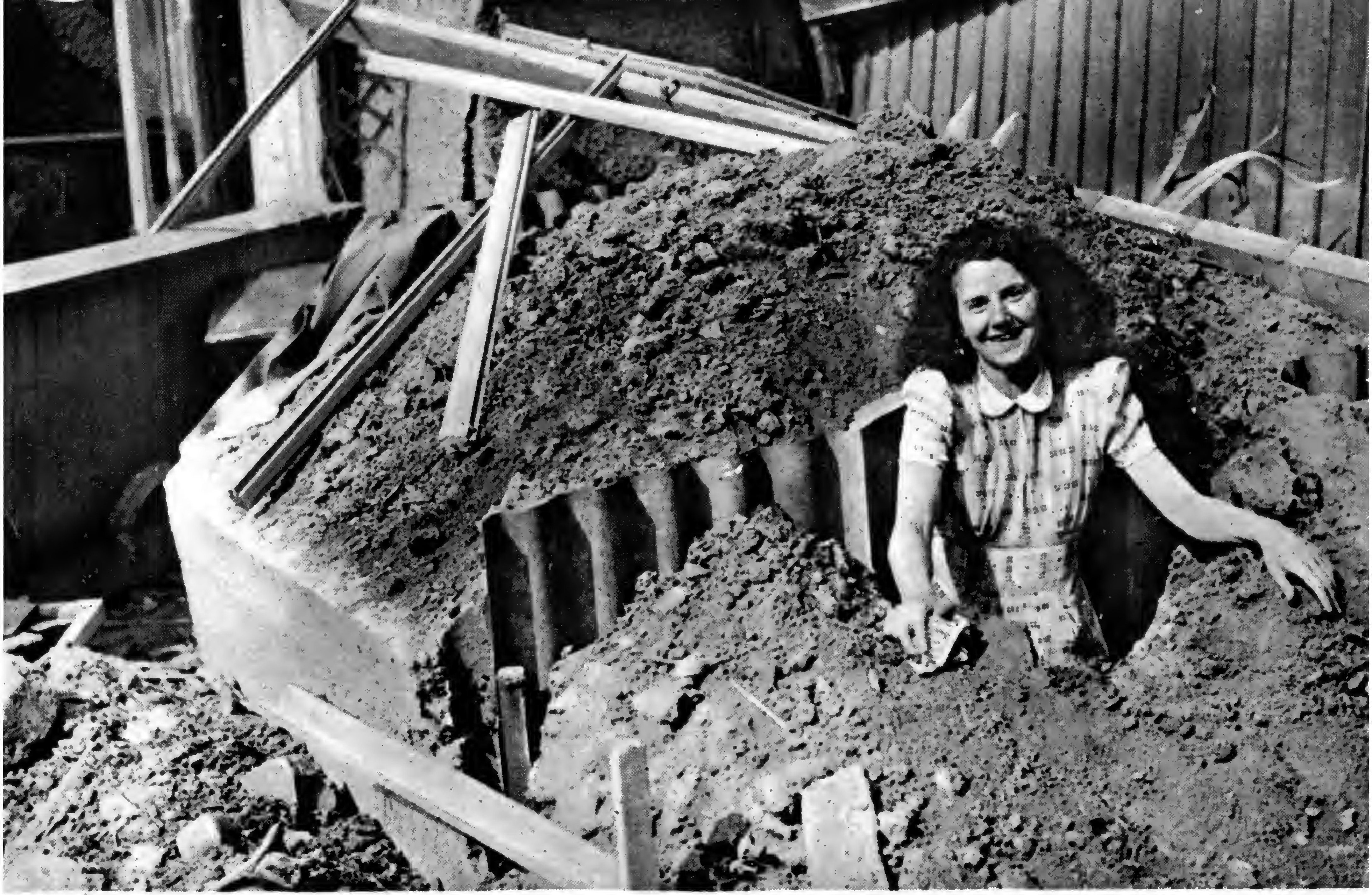
A CRATER, 25 FT. DEEP, OUTSIDE A DAMAGED HOUSE IN CROYDON. ALL THE OCCUPANTS OF THE SHELTERS ESCAPED INJURY. *(Topical.)*

HARDLY THE "COWERING" LONDONERS OF DR. GOEBBELS' IMAGINATION: A CHEERFUL NORTHFLEET FAMILY SITTING BY THEIR SHELTER AFTER A RAID. *(Fox.)*

AN UNDAUNTED MIDLAND FAMILY, DUG OUT AFTER A BOMB HAD BURST BEHIND THEIR SHELTER—WHICH SAVED THEM. *(A.P.)*

MR. AND MRS. SHERMAN, OF CROYDON, WITH THEIR BABY, BY THEIR SHELTER, ON EACH SIDE OF WHICH BOMBS BURST. *(G.P.U.)*

GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. *(Planet.)*

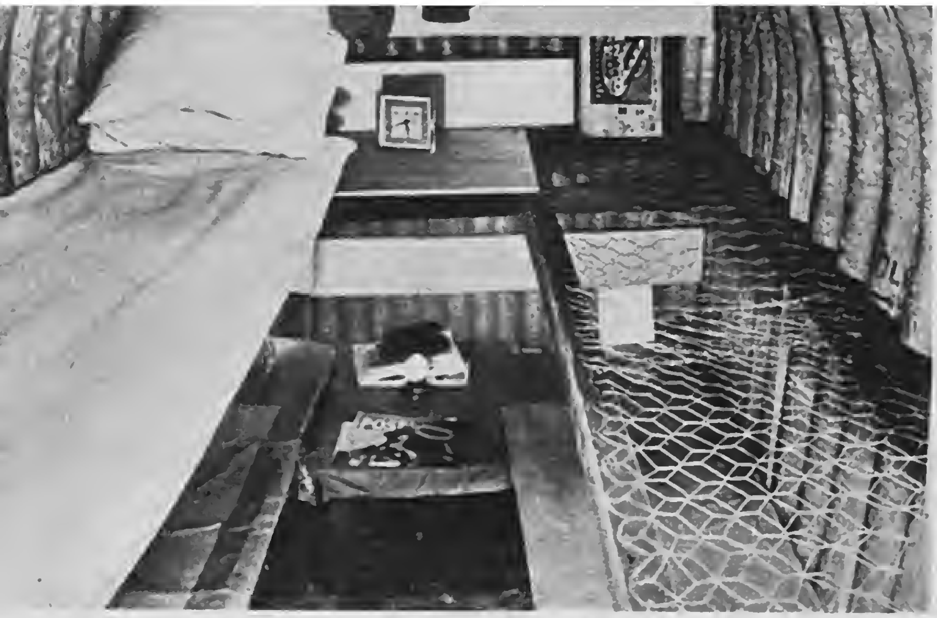


ILLUSTRATED LONDON NEWS—Aug. 24, 1940

GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. *(Planet.)*

(Picture Post, 1940)

Why not be COMFORTABLE?

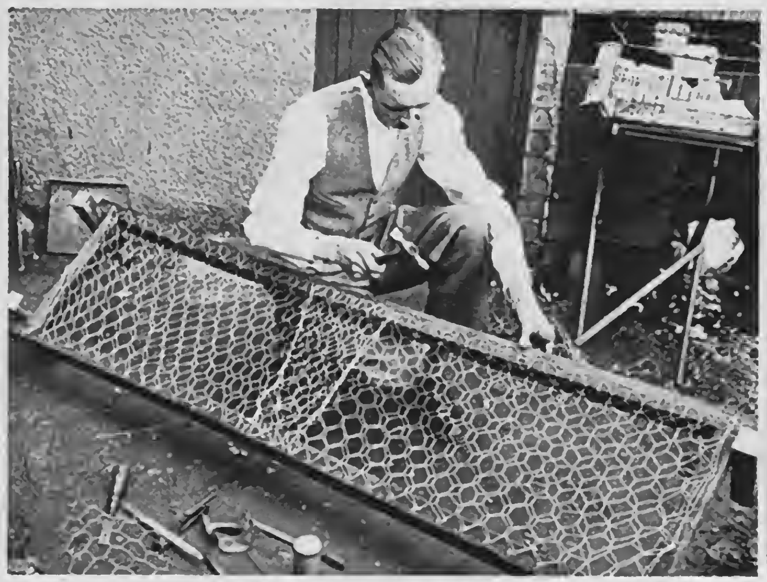


WHAT YOU CAN DO WITH AN ANDERSON

As comfortable as a ship's cabin, with two upper berths and two lower. Mr. Stuart Murray, PICTURE POST reader, has converted his shelter into a satisfactory sleeping place. The pictures below show you how he did it.

Long winter nights are ahead. With a little ingenuity you can make them tolerable by fitting your Anderson shelter with home-made bunks.

A MONTH ago we published a letter from a reader, Mr. Stuart Murray, suggesting how an Anderson shelter could be made fit not only for protection, but for a night's sleep. We passed on his suggestion, and a number of other readers wrote in to ask for a fuller explanation. Here it is. Our photographer went down to Mr. Murray's home in Croydon and took these pictures showing how, with a little ingenuity, he has turned his shelter into a family bedroom. Some lengths of timber, and a few yards of chicken wire netting are all the extra materials that are needed. Most people will find it easy to get hold of the small quantities required for the bunks. Bedding, and any extra comforts you need imported from the house, will make the shelter a good deal more tolerable for an all-night session. It costs very little. It is not a difficult job. And, once done, it will mean a good deal to the health and nerves of yourself and your family.



1 *Take some pieces of 2 in. by 2 in. timber. Cut them to lengths of 6 ft. 6 in. and 22 in., the first measurement giving the length, the second the width for the framework of your bunk. Over this stretch and fix doubled chicken wire, with an extra thickness in the centre where it is most likely to sag.*

2 *Every Anderson shelter has a steel girder. You build your upper bunk with supports that rest on the girder. The top bunks are 4 ft. from the floor, the lower bunks 18 ins. You can do your carpentering in the garden outside the shelter, and slip the finished bunks endways in through the door.*

3 *The top berth is hoisted into place. When the wooden support rests on the metal girder it allows ample breathing space between the upper and lower bunks.*

4 *For comfort. Packing-case boarding fixed at an angle provides substitute bolster on which pillow rests. Shelves nailed between bunks add to steadiness.*

5 *And so to bed. Your timber and chicken wire frame work, transformed with blankets and pillows, becomes, if not a bed of roses, a tolerable resting-place.*

UK NATIONAL ARCHIVES: ES 5/2

ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

AWRE-T1/54, 27 Aug. 1954

SECRET—GUARD

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE

(Monte Bello Islands, Australia—October, 1952)

12.1. *Blast Damage to Anderson Shelters*

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

Operation Hurricane nuclear test Anderson shelters used sandbags which gave no "earth arching" protection, unlike packed soil cover used over London Anderson shelters, 1940:

13. The Penetration of the Gamma Flash

13.1. *Experiments on the Protection from the Gamma Flash afforded by Slit Trenches*

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

Table 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

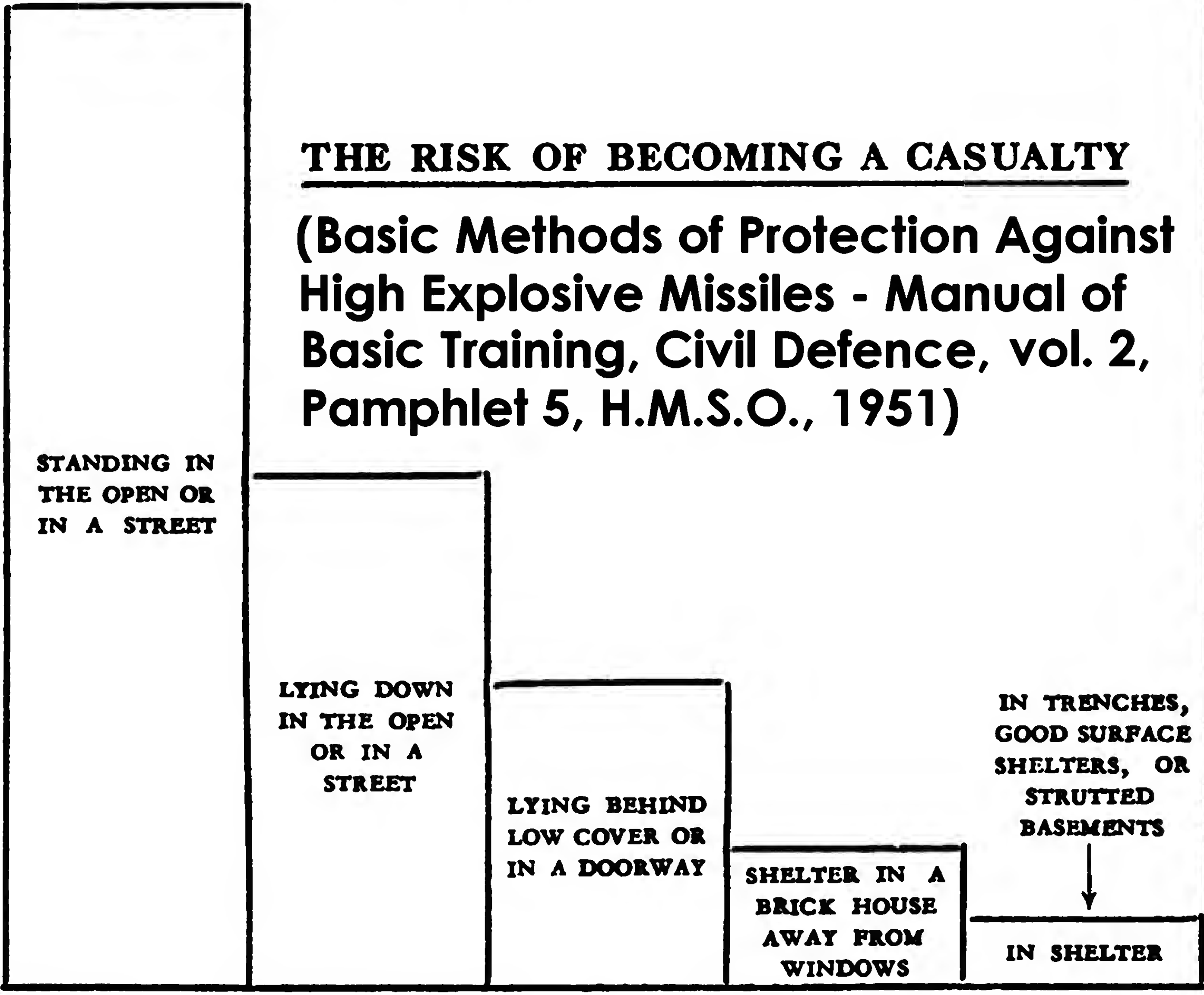
Type of trench	Rectangular broadside-on open			Rectangular end-on open	Circular open		Rectangular broadside-on covered	
Distance (yards) ...	1,300	943	733	1,300	1,300	943	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	300	3,000	3,000	14,000
Depth below ground level (inches)								
6 ...	150	1,000	—	230	214	1,200	(75)	—
12 ...	75	430	—	150	120	545	47·6	—
24 ...	33·3	150	584	60	54·5	188	25	(140)
36 ...	23	70	216	31·6	30	86	13	(56)
48 ...	(20)	43	100	20	17·7	48·5	7·7	(31)
60 ...	—	(37·5)	61	13·6	10·7	(33·3)	5	(23)
72 ...	—	—	(46·7)	(8·6)	7	—	(3·5)	—

Entries in brackets are extrapolations or estimates.

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.

THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)




Type 3 outdoor Anderson shelter

Anderson shelters exposed to Operation Hurricane nuclear test

Anderson shelter with earth cover (not sandbags) and radiation-shielded entrance at Home Defence College, Easingwold, York, 1980.

Earth covered shelter, Hiroshima (U.S. Strategic Bombing Survey)

November 1940 design by C. A. Joy, M. Inst. Me. & C. E., Bexley Borough Engineer (UK National Archives: HO 205/257)

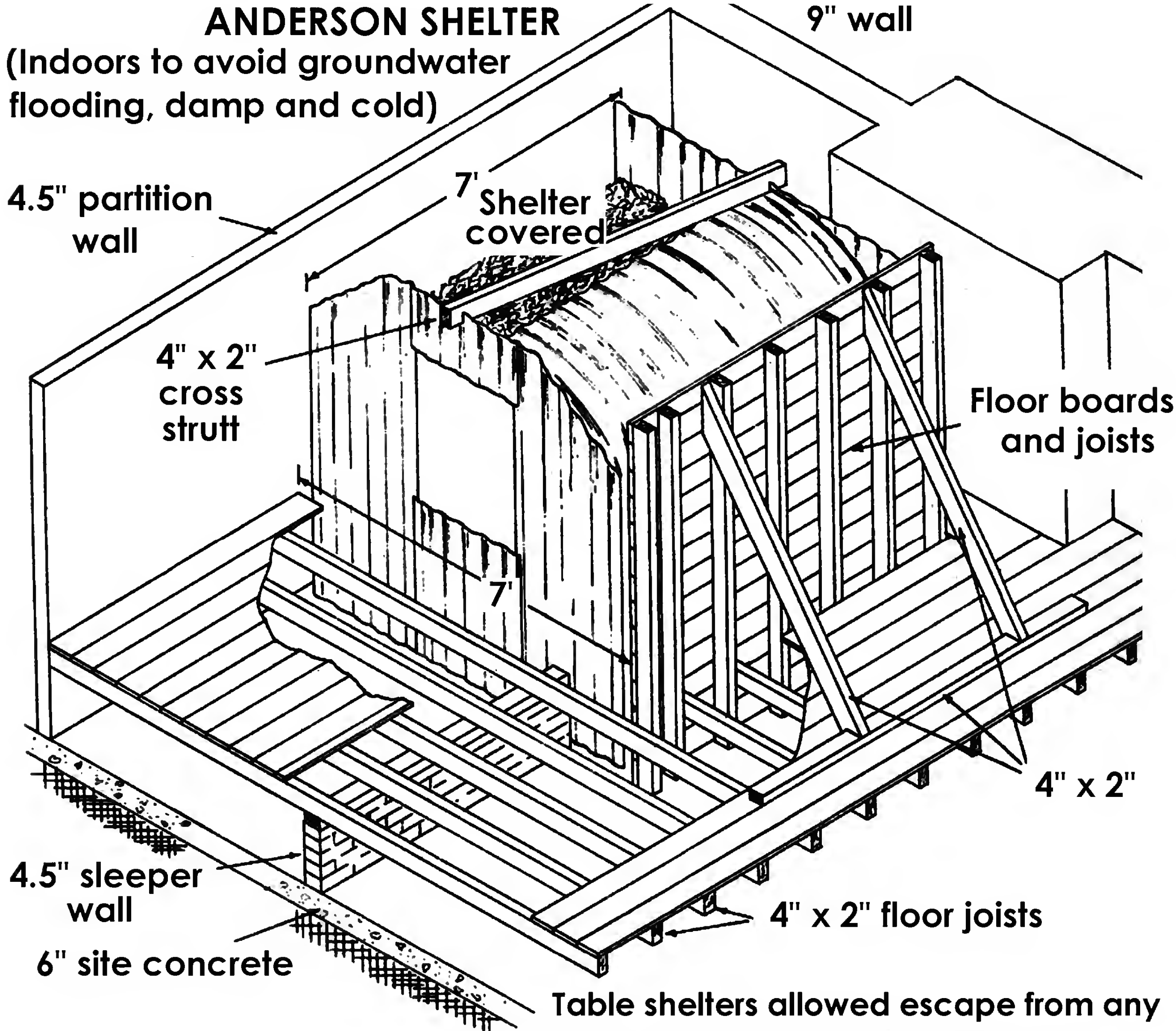
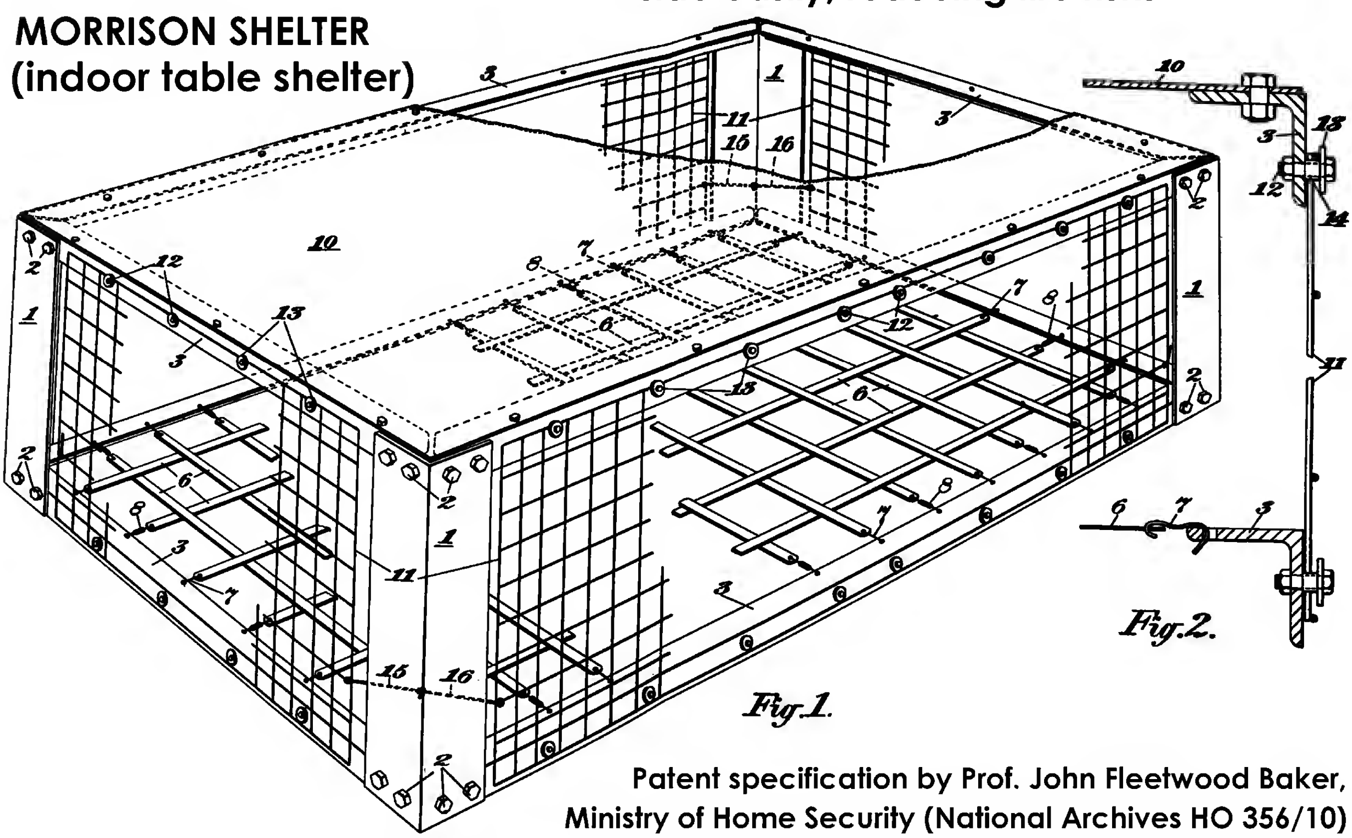
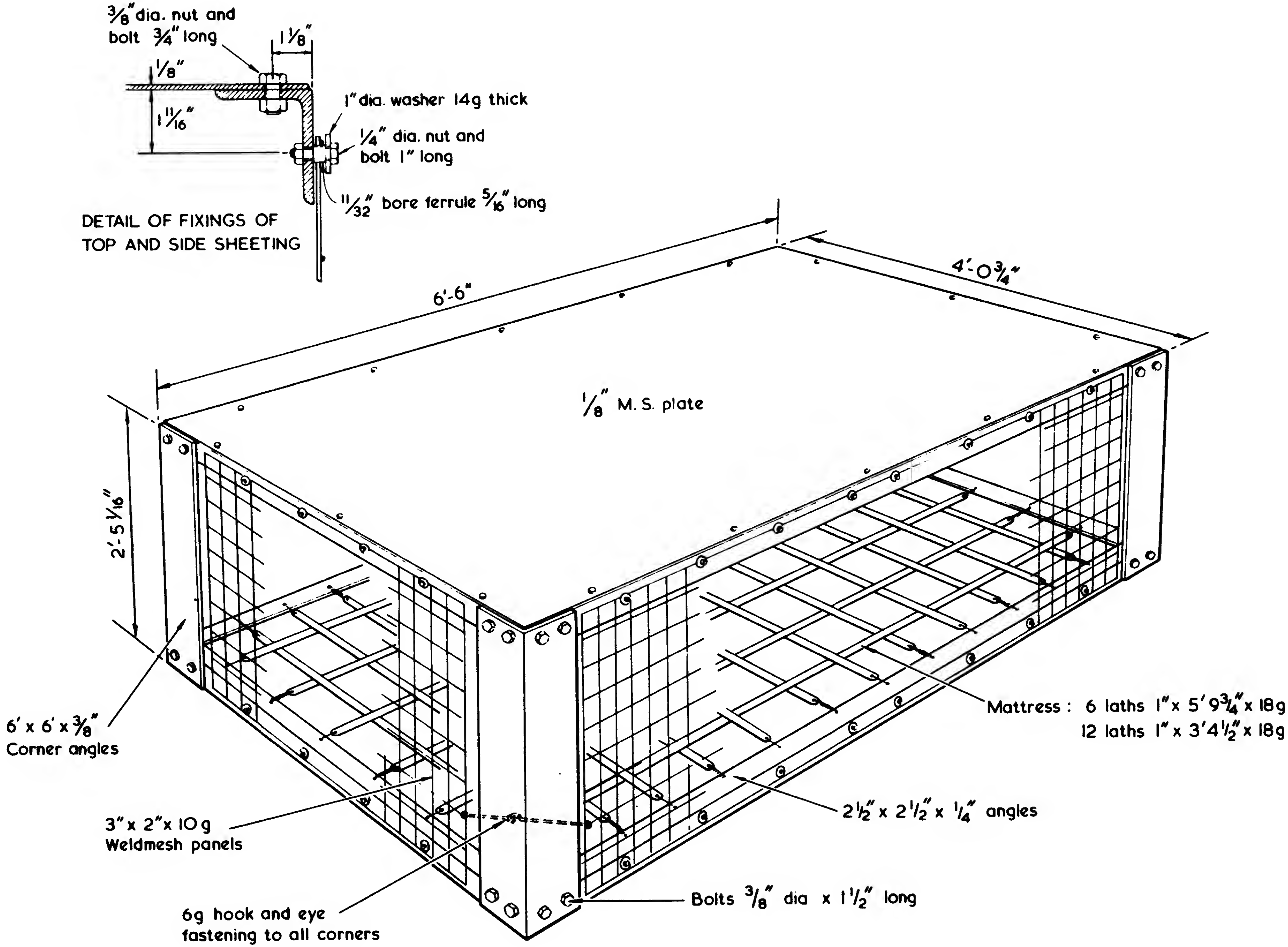


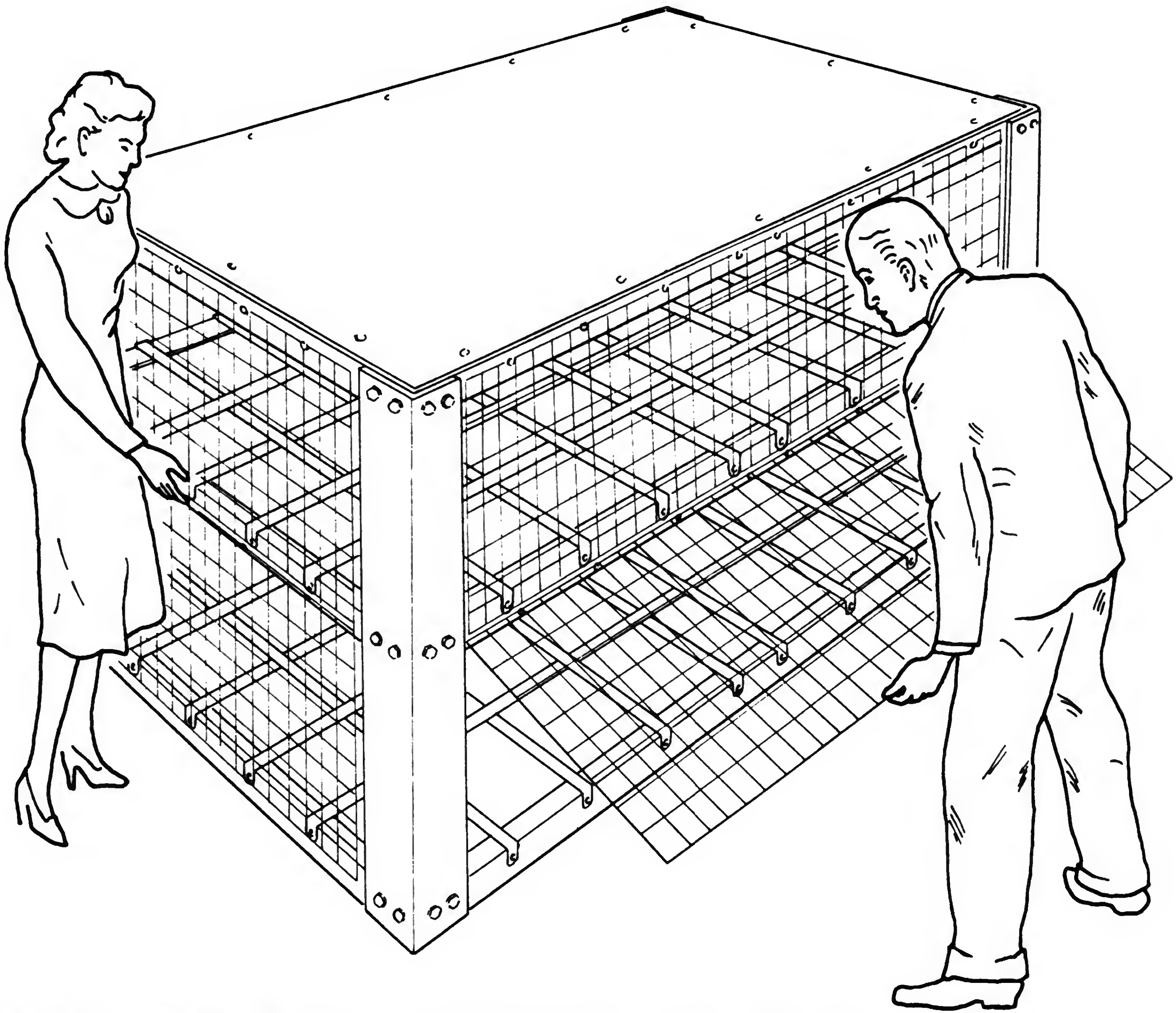
Table shelters allowed escape from any side easily, reducing fire risks



Patent specification by Prof. John Fleetwood Baker, Ministry of Home Security (National Archives HO 356/10)



MORRISON SHELTER : FINAL DESIGN

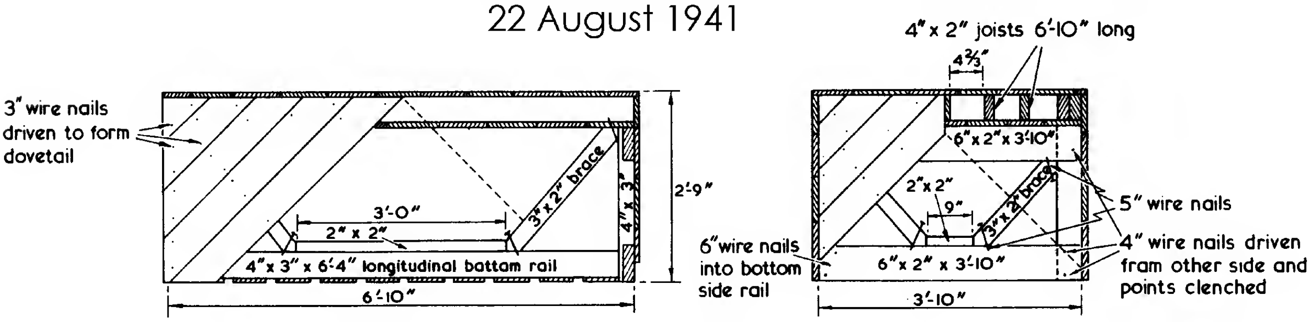


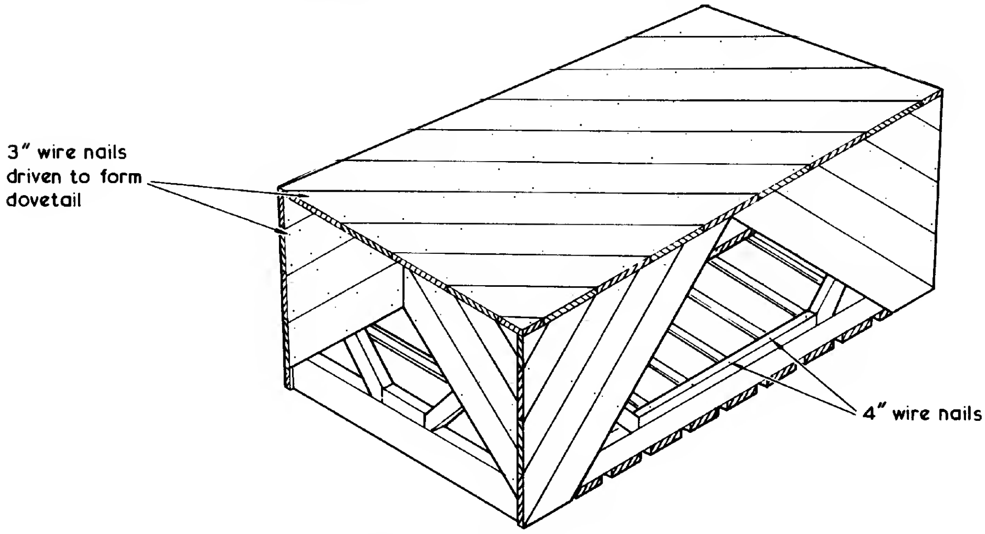
Bunk bed Morrison shelter for large households

Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential). Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness.

National Archives
HO 195/16

PROOF-TESTED WOODEN VERSION OF MORRISON INDOOR TABLE SHELTER
UK Home Office Research and Experiments Department Bulletin C21, 22 August 1941

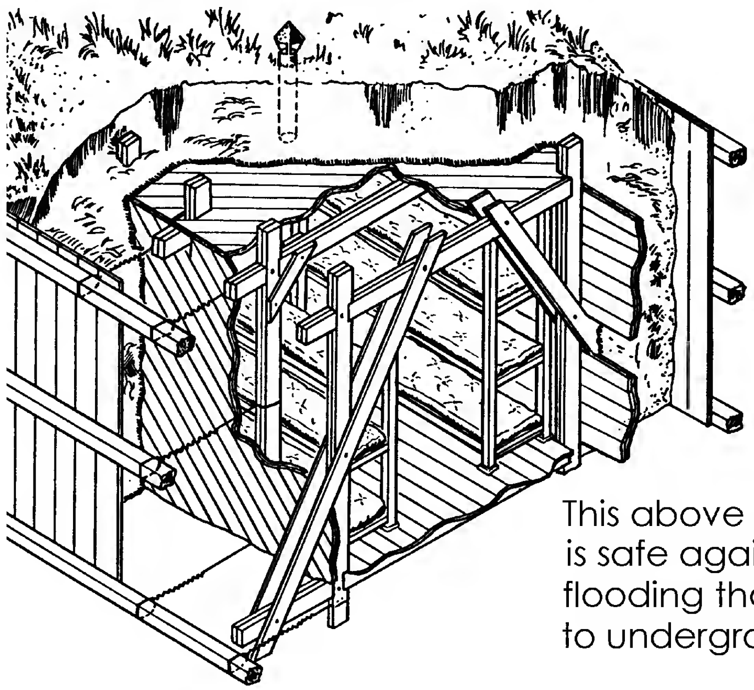




Survived house collapse intact.

This wooden table shelter used "salvage timber from blitzed houses of which 20 shillings worth could be bought per month without a licence, ... the recommended material. ... The cost of materials including nails and fire retarding paint varied from £3 to £4.10s ... This shelter passed the Research and Experiments Department's tests with flying colours." - Lord Baker, *Enterprise versus Bureaucracy: The Development of Structural Air-Raid Precautions During the Second World War,* 1978, p80.

PROOF-TESTED OUTDOOR ABOVE GROUND WOOD AND EARTH SHELTER



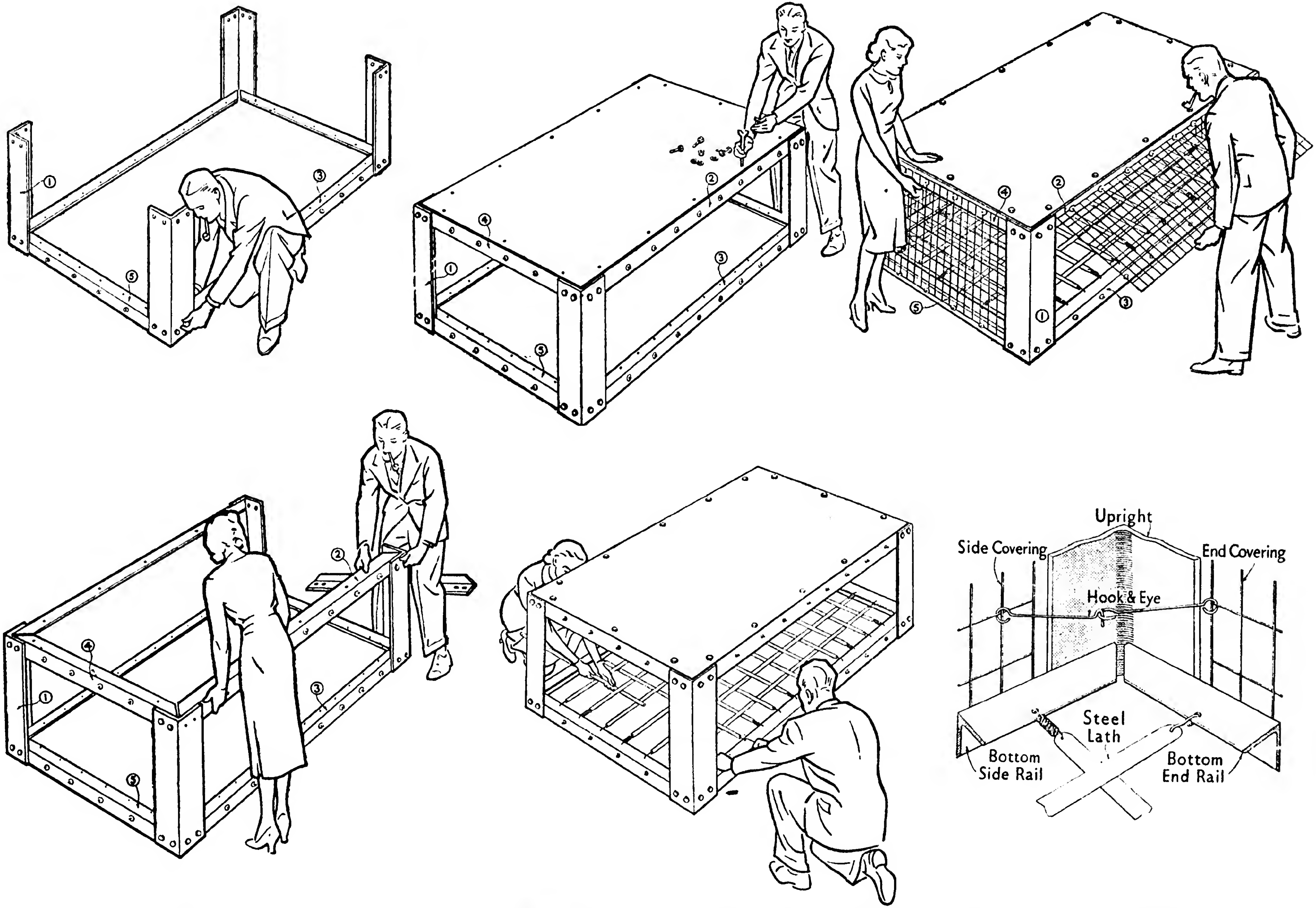
No casualties in test at 20 ft (250 kg TNT)

(Minor damage to shelter from the crater debris)

This above ground shelter is safe against ground water flooding that occurs in winter to underground shelter/trench.

UK Home Office Research and Experiments Department Bulletin C26, *Timber shelters for countries where timber is plentiful and steel difficult to obtain,* April 1942. This is a surface (not underground) wooden shelter with 2.5 ft earth fills in the gap between two wooden walls, and on roof.

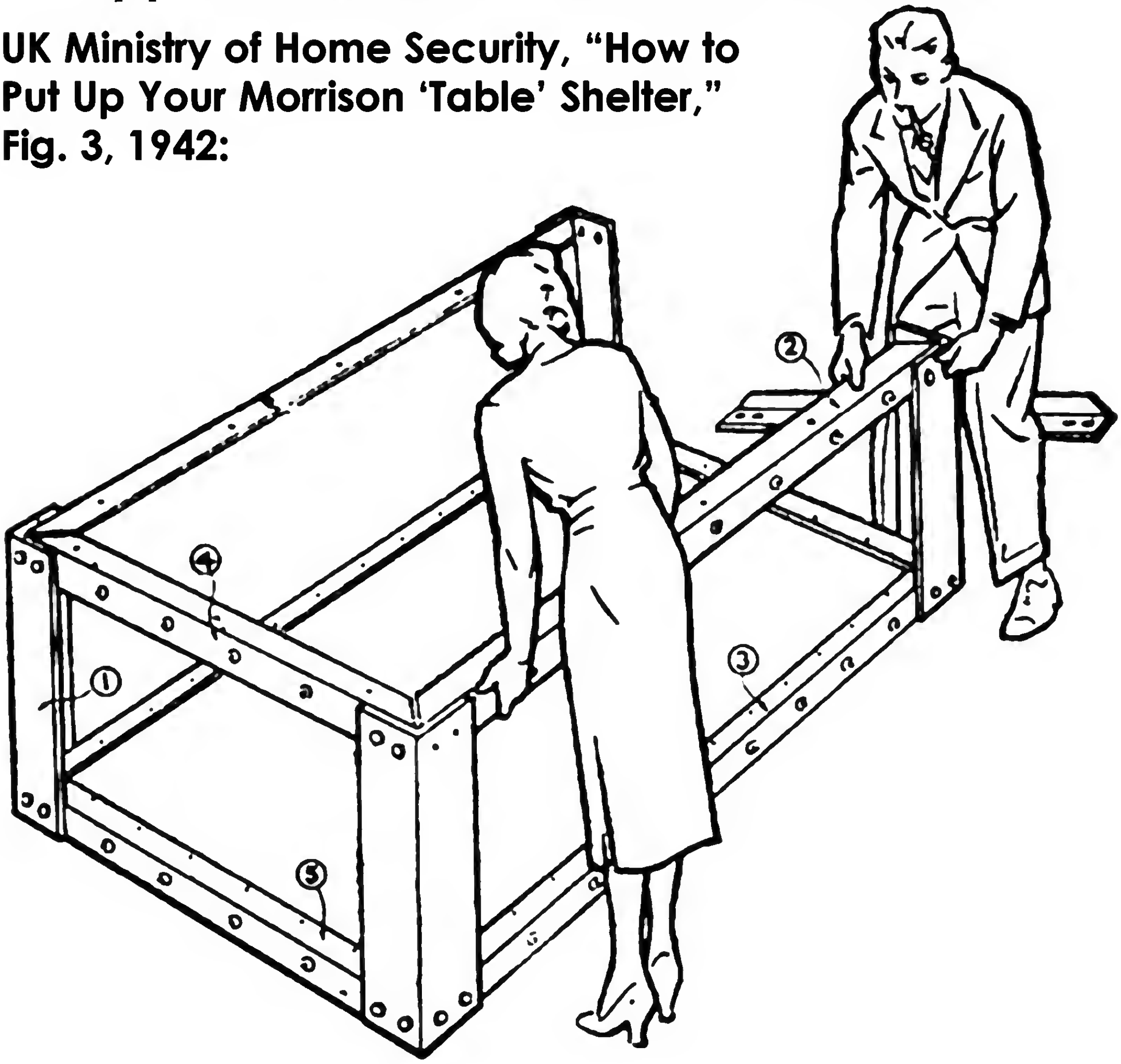
NOTE: UK Home Office civil defence department was the "Ministry of Home Security" in wartime.



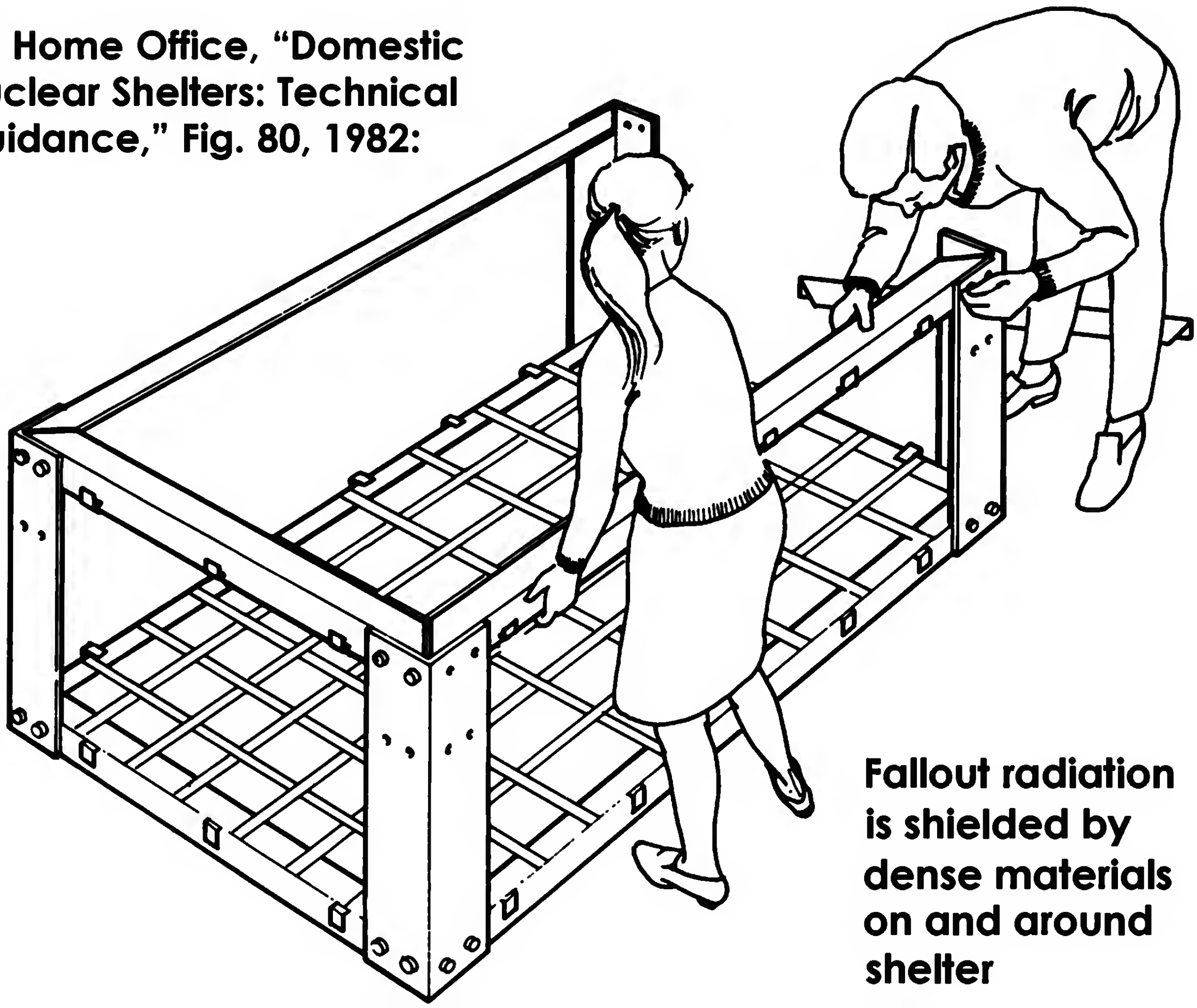
How to Put Up Your "Morrison" Steel Table Shelter, 1942

Type 2 indoor Morrison shelter

UK Ministry of Home Security, "How to Put Up Your Morrison 'Table' Shelter," Fig. 3, 1942:



UK Home Office, "Domestic Nuclear Shelters: Technical Guidance," Fig. 80, 1982:



Fallout radiation is shielded by dense materials on and around shelter

National Archives
HO197/24

Morrison Shelters in Recent Air Raids.

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrisons" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.

SECRET.

W.P.(G)(41)7. COPY NO. 62

January 15th, 1941.

WAR CABINET.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

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6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

(i) that proposals for building shelters of massive construction should be rejected;

(ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;

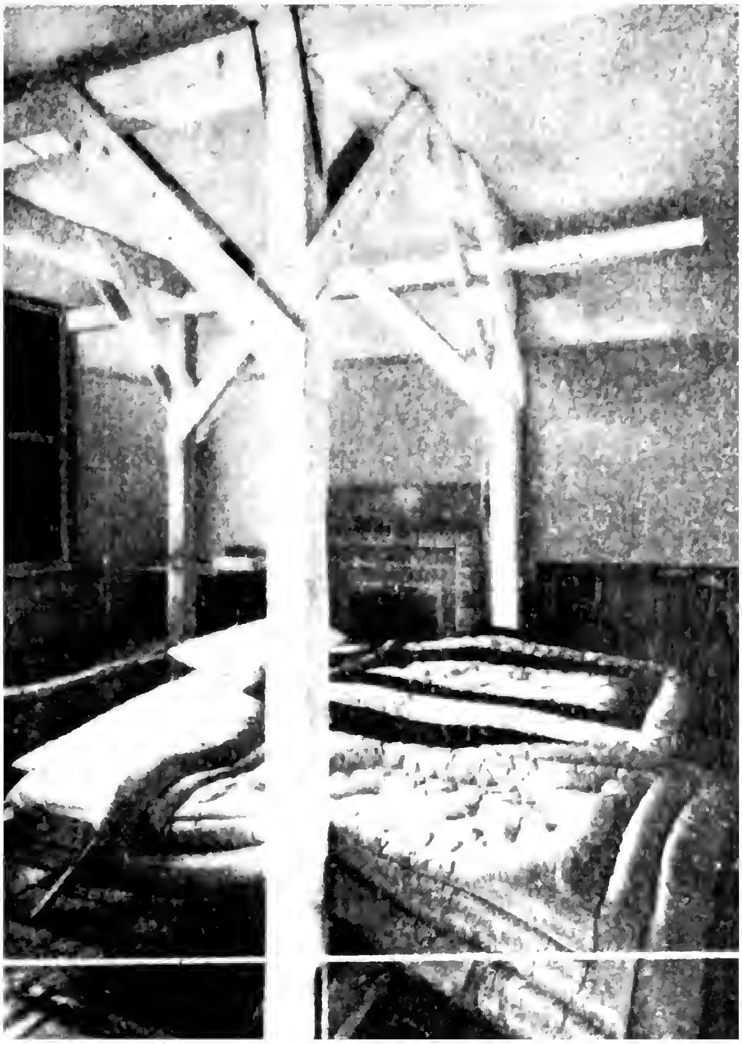
(iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

H.M.

MINISTRY OF HOME SECURITY.

January 15th, 1941.

June 1941



SHELTER at home

3d. ISSUED BY THE MINISTRY OF HOME SECURITY
AND PUBLISHED BY H.M. STATIONERY OFFICE

Introduction

Not everyone wants to leave home for shelter. Some people can't. Lots of people just prefer to remain in their own house anyway. This inclination is a natural one. It is a sound instinct too, if some protection can be found against the collapse of walls and ceilings.

Shelter indoors allows you to sleep at night in reasonable security and in the warmth and comfort of your house. It also provides handy cover should there be a sudden raid in the day time.

A direct hit cannot be guarded against in any form of home shelter, but the risk of such a direct hit is very small compared with that of a bomb bursting near enough to damage the house or to demolish it. Protection can be obtained in a house even if a bomb demolishes most of it.

The walls, floors and roof of an ordinary house give quite a lot of protection against splinters and blast from a bomb. The idea of an indoor shelter is to make use of this protection and to add safeguards against the other effects of bombs.

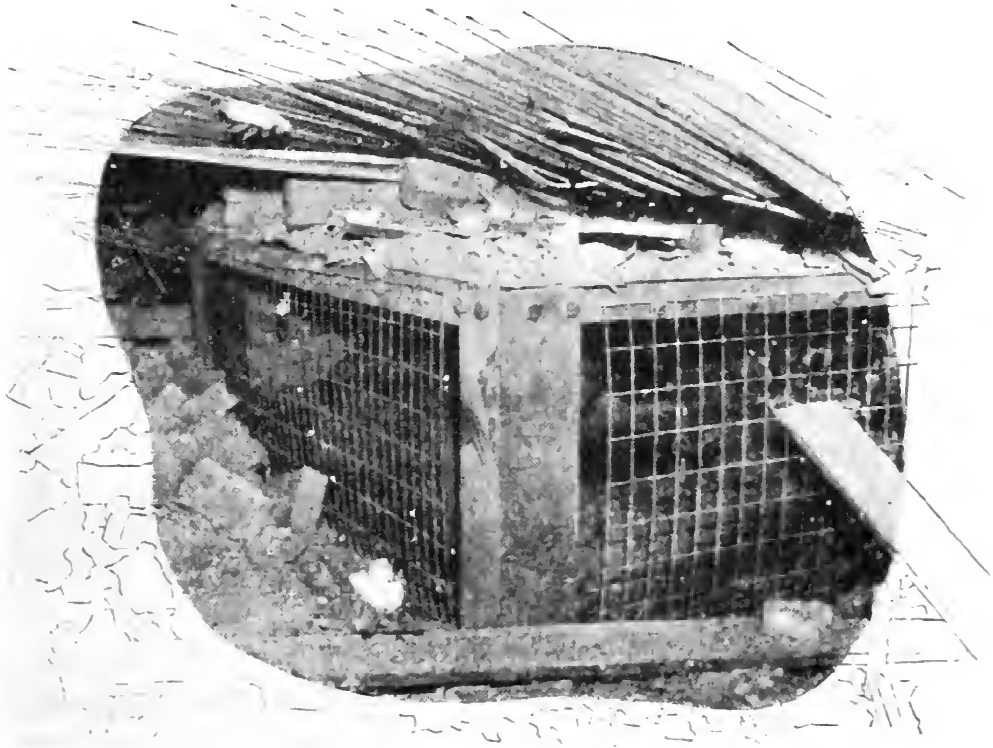
The chief of these is the danger of the house falling down. People have often been rescued unhurt from the ruins of demolished houses because they had taken shelter under staircases, or tables, that had by chance been strong enough to protect them from the falling ruins of the house. The chief purpose of the indoor shelters described in this pamphlet is to protect the occupants against injury when the bedroom floor, the roof and other débris fall on them.

They do not provide such easy emergency escape as a garden shelter, but if you are trapped they protect you from the débris till the Rescue Party releases you. Very often, however, though the house has fallen you will be able to release yourself and walk out.

The indoor shelters with which this pamphlet deals are unsuitable for houses with more than two storeys above the shelter room. They are intended chiefly for use in ordinary two-storey houses, but have a margin of strength that will take the weight of an extra storey.

ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.



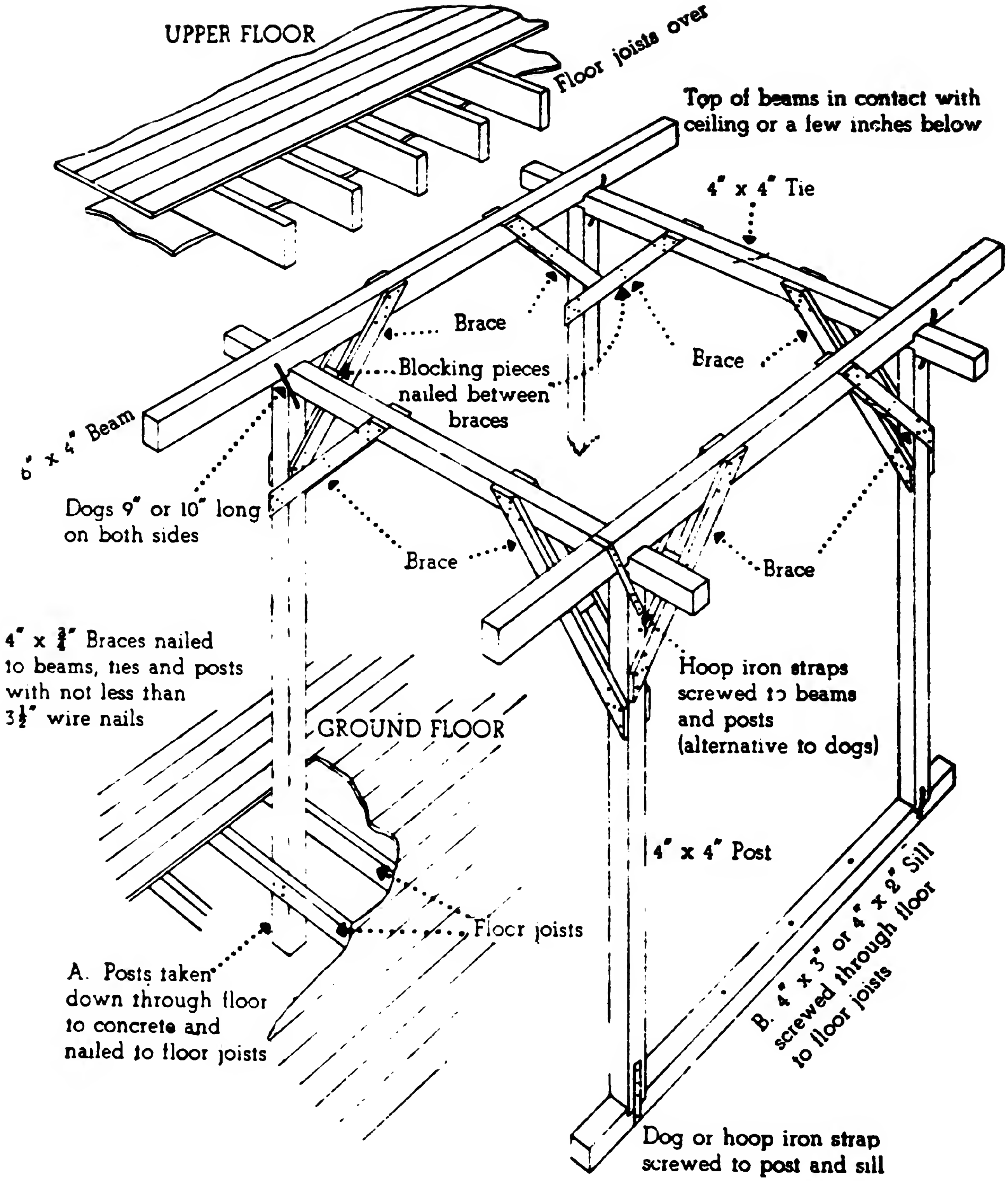


ILLUSTRATION NO. 11. Independent timber framework for a refuge room. If the posts are more than 6 ft. 6 in. apart, 8 in. × 4 in. beams are desirable.

A home-made shelter

You will have noticed earlier in this booklet the statement that people have often been rescued from demolished houses because they had taken shelter under an ordinary table. This was because the table had by chance been strong enough to bear the weight of the falling bedroom floor. A timber framework can be built inside a refuge room to do the same thing, but with certainty. ILLUSTRATION NO. 11 shows a completed framework

1 HB-8
The house at Main and Elm Streets. Two typical colonial two-story center hall frame dwellings were placed at 3,500 and 7,500 feet from the bomb tower. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

X-19
This mannequin can only stay in the position in which he was placed, staring through the window at coming disaster. A real occupant of this house could prepare—and survive. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

1 HA-11
House No. 1, from the camera tower from which the dramatic collapse pictures were taken. The Post Office truck to the left, although it lost all windows and suffered body damage, was driven away later, as was the car in the rear of the house. Entry to the basement was made through the corner at lower center. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

LSA-2
3,500 feet from ground zero. The house overhead is totally destroyed, some of it has fallen into the basement, but the mannequin in the lean-to shelter is undisturbed. The photo was taken from ground level, looking into the basement through the gap between the basement wall and the broken floor timbers. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

Detonation time | 0.4 second | 0.5 second: blast blows up roof

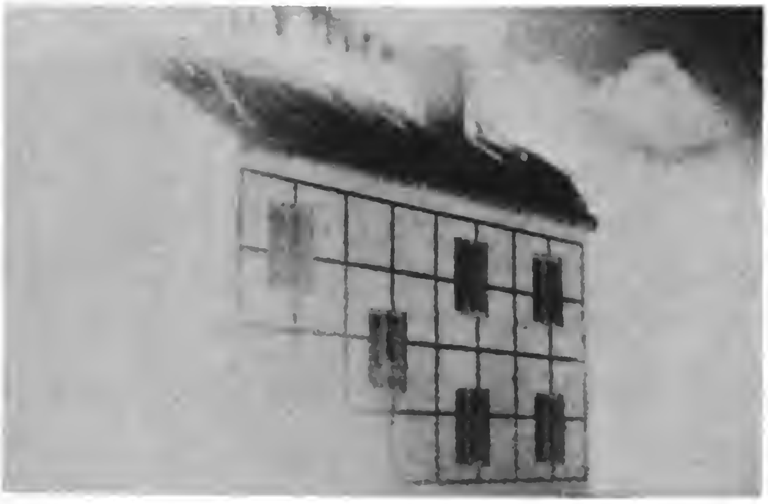
0.7 second: roof panels blow off | 0.8 second | 1.1 second

1.3 second | 1.5 second | 1.6 second

1.7 second | 2.0 second | 2.1 second

47 kt EASY nuclear test at Eniwetok Atoll in 1951, exposing a brick house to 3 psi peak overpressure.

Walls withstood blast although light roof panels were blown off. Repair cost = 10% of rebuild cost.



47 kt Greenhouse Easy, Eniwetok Atoll, 1951. Brick house, 3 psi peak overpressure

0.6 second

Impact + 1.0 second

Afterward

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

40. The provision of air raid shelters throughout Japan was much below European standards. Those along the verges of the wider streets in Hiroshima were comparatively well constructed : they were semi-sunk, about 20 ft. long, had wooden frames, and 1 ft. 6 ins. to 2 ft. of earth cover. One is shown in photograph 17. Exploding so high above them, the bomb damaged none of these shelters.

41. In Nagasaki there were no communal shelters except small caves dug in the hillsides. Here most householders had made their own backyard shelters, usually slit trenches or bolt holes covered with a foot or so of earth carried on rough poles and bamboos. These crude shelters, one of which is shown in photograph 18, nevertheless had considerable mass and flexibility, qualities which are valuable in giving protection from blast. Most of these shelters had their roofs forced in immediately below the explosion ; but the proportion so damaged had fallen to 50 per cent. at 300 yards from the centre of damage, and to zero at about ½ mile.

42. These observations show that the standard British shelters would have performed well against a bomb of the same power exploded at such a height. Anderson shelters, properly erected and covered, would have given protection. Brick or concrete surface shelters with adequate reinforcement would have remained safe from collapse. The Morrison shelter is designed only to protect its occupants from the debris load of a house, and this it would have done. Deep shelters such as the refuge provided by the London Underground would have given complete protection.

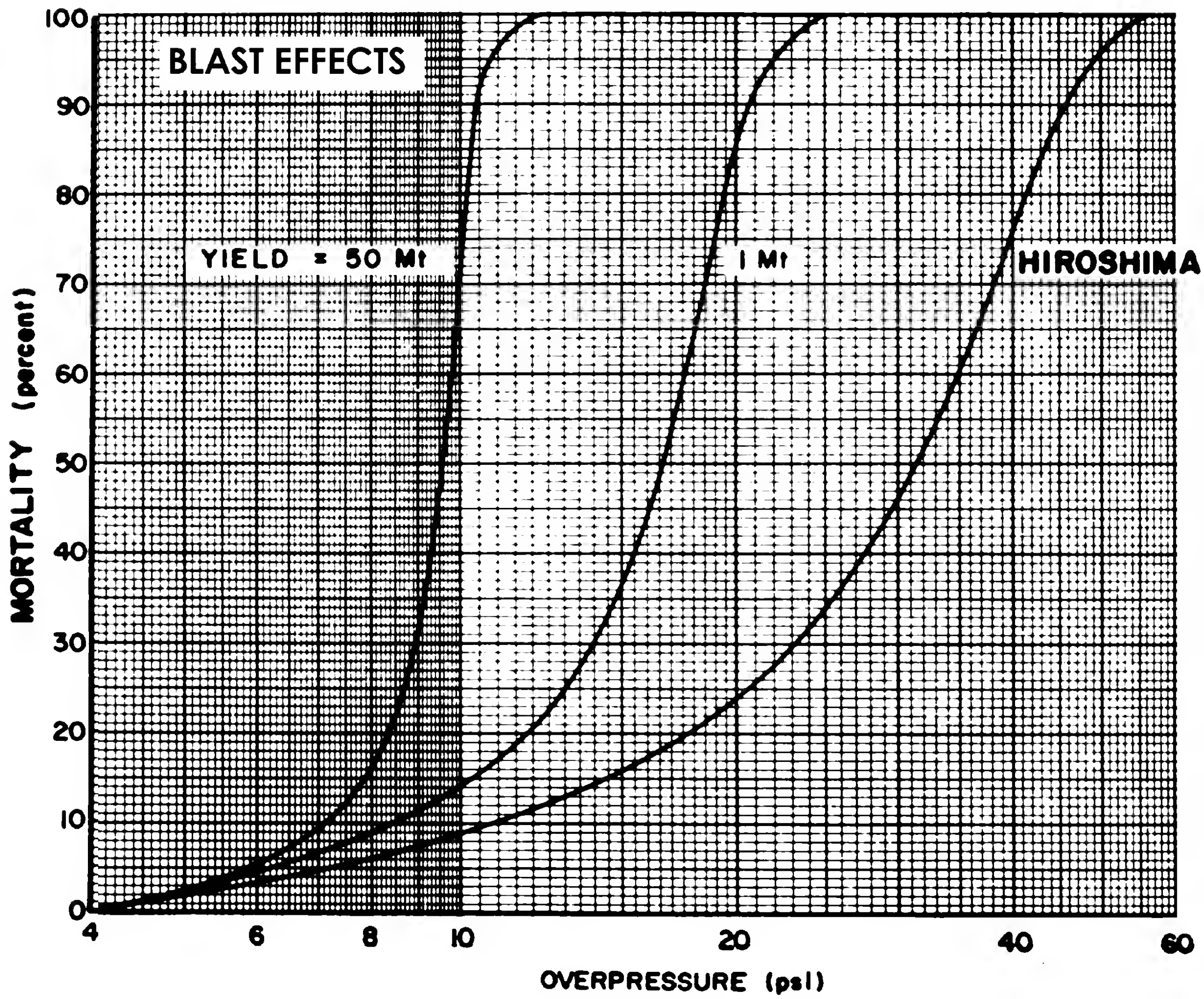
LONDON

1946

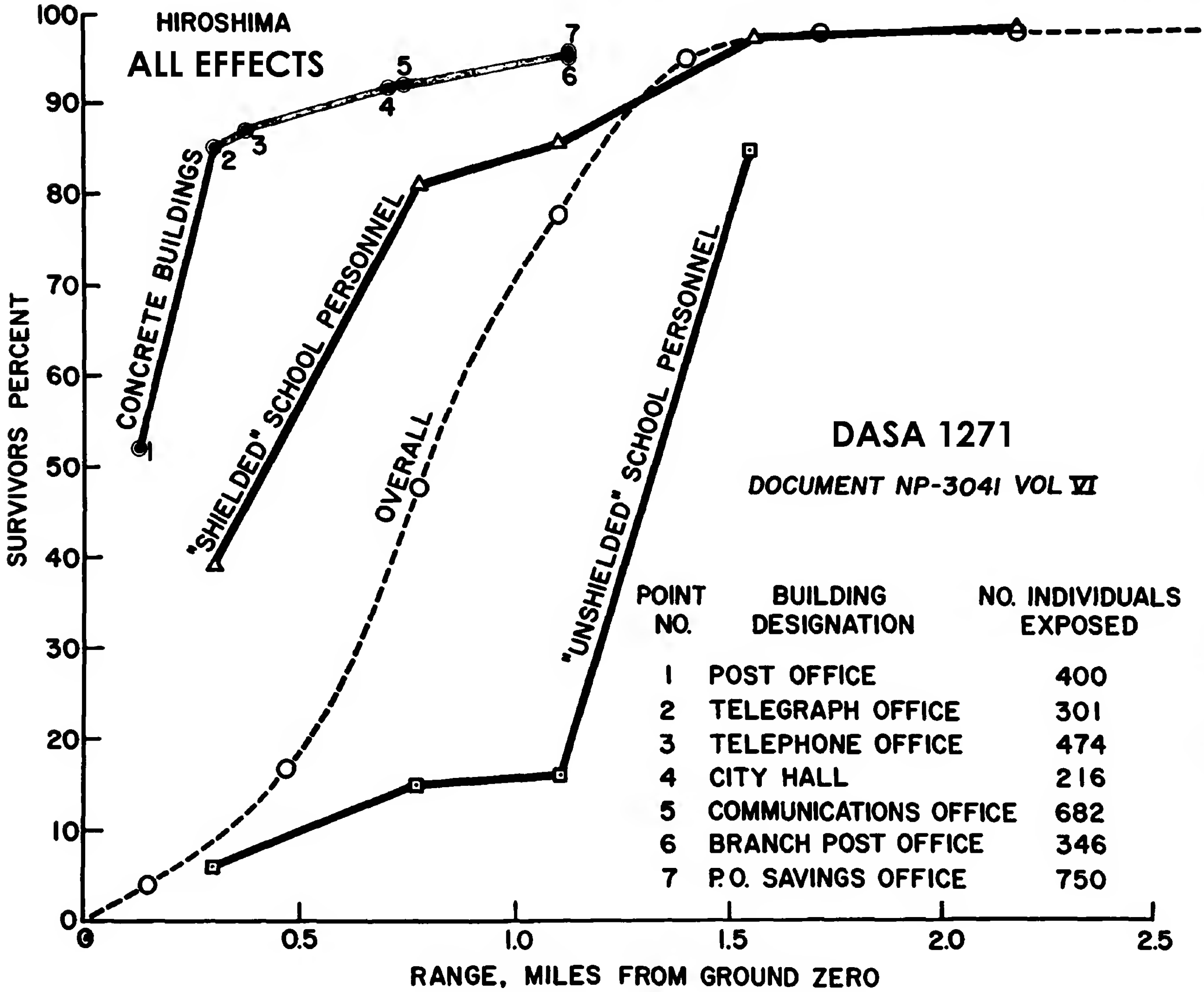
Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to "flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties.

Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage.

DC-P-1060 **NONSEISMIC REINFORCED-CONCRETE BUILDINGS**

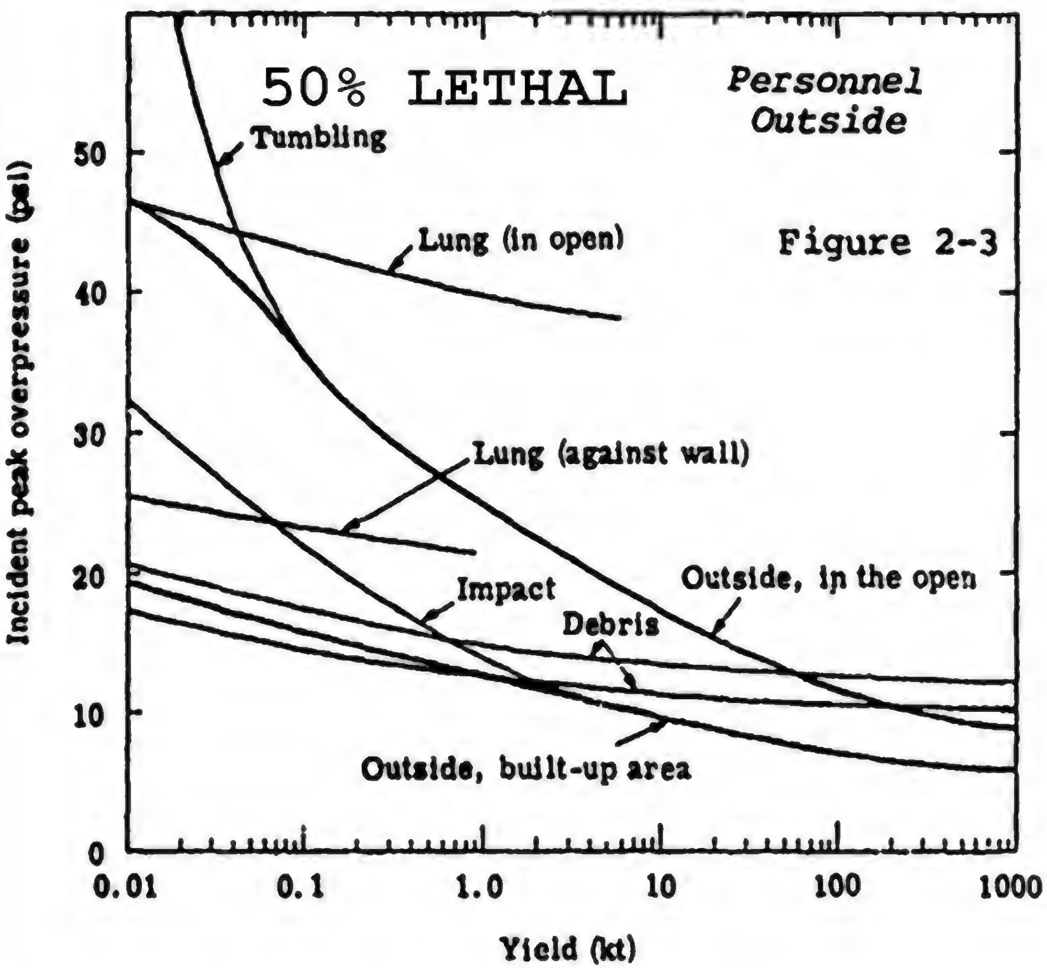


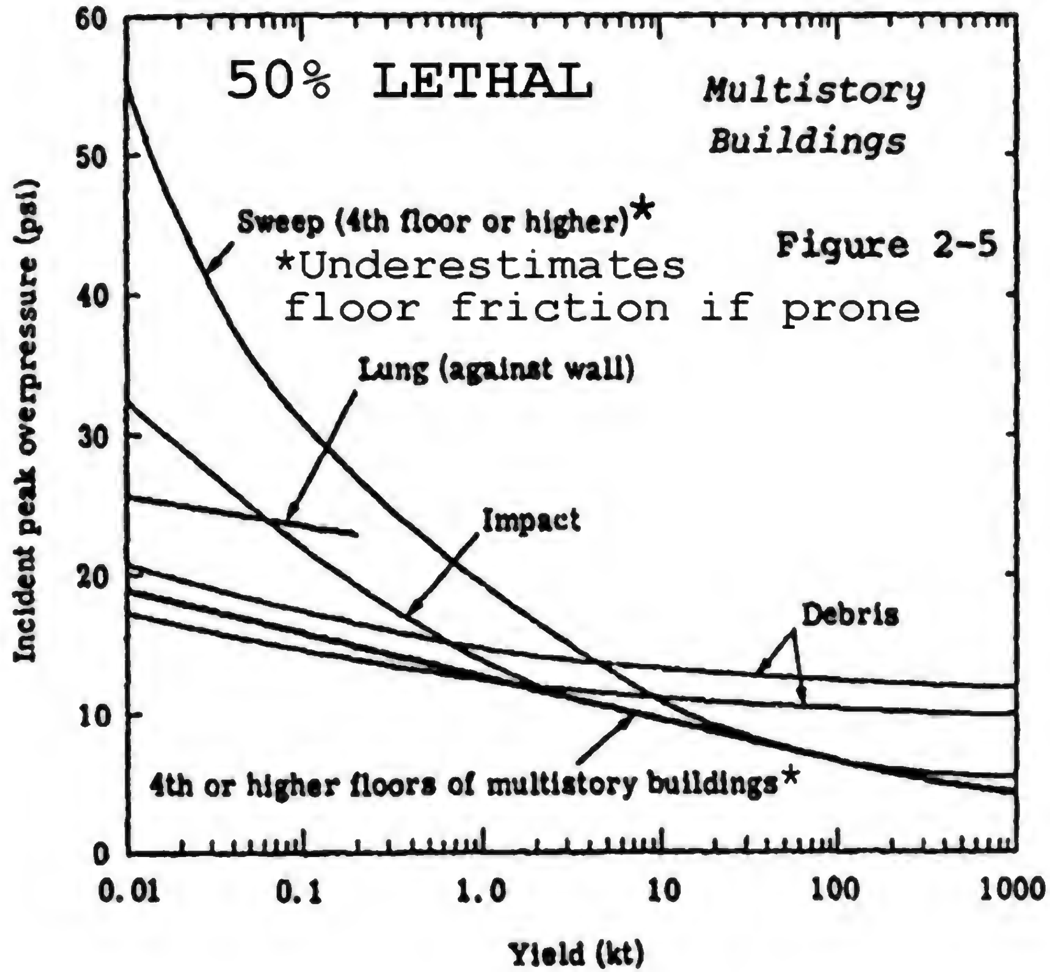
L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation



Ashley W. Oughterson, et al., Medical Effects of Atomic Bombs, NP-3036 to NP-3041 (Vols. I-VI), Army Institute of Pathology; 1951.

Dr Martin P. Fricke (Science Applications International Corp., California), "Preliminary Civilian Casualty Criteria for Low-Yield Nuclear Weapons," DNA-3547T, 1975.





29 kt Teapot-Apple 2 test, 5 psi peak overpressure

exterior walls were exploded outward, so that very little masonry debris fell on the floor framing. The roof was demolished and blown off, the rear part landing 50 feet behind the house.

S. Glasstone, Effects of Nuclear Weapons, 1964, p208
Wall brick debris was blown out, not in on to people!

ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.

(Page 11 from the June 1941 UK Ministry of Home Security "Shelter at Home" handbook.)

Morrison shelter saves lives of Mr McGregor pictured beside Morrison shelter, as well as his wife and lodger, in collapsed house, York 1942 air raid

Morrison indoor table shelter test by Ministry of Home Security, 1941: result shelter survived and occupants would have escaped unaided. (Source: "Shelter at Home", June 1941 handbook.)

Morrison shelter saves lives of Mr McGregor (pictured beside Morrison shelter), as well as his wife and lodger, in collapsed house, York 1942 air raid

UK National Archives: HO 192/909

Morrison shelter surviving 250 kg direct hit on 12 March 1943

on house at 10 Fore Street, Salcombe (Mrs Hannaford)

WWII Surface shelter (UK National Archives INF 13/218)

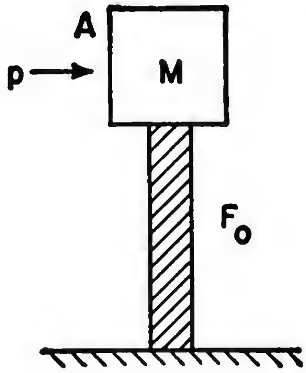
Glasstone, "Effects of Atomic Weapons", 1950, App. A

APPENDIX A[1]

[1] By C. W. Lampson and S. B. Smith.

AN APPROXIMATE METHOD OF COMPUTING THE DEFORMATION OF A STRUCTURE BY A BLAST WAVE

Blast wave energy is absorbed, pushing a structure

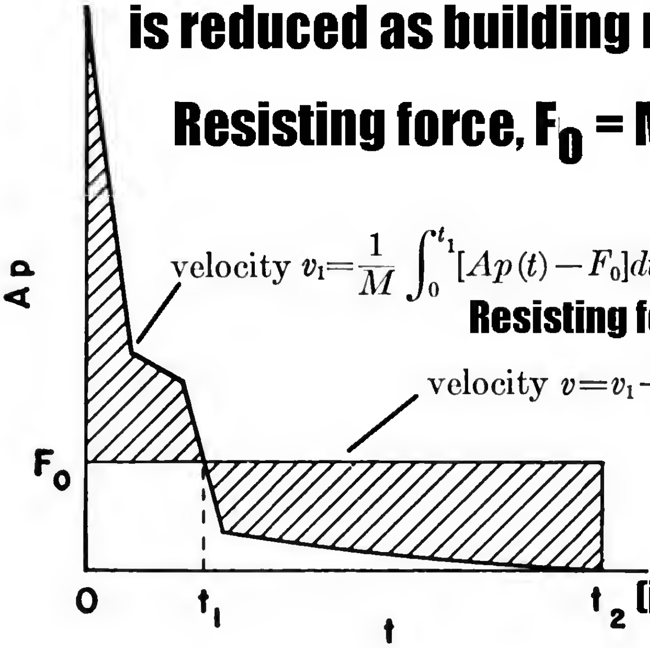


$$M\frac{d^2x}{dt^2}=Ap-F_0$$

M is the mass of the structure, i. e., w/g,
F_0 is the resisting force of the structure,
x is the deformation of the center of mass,
A is the area of the front face,
$p(t)$ is the effective blast pressure acting

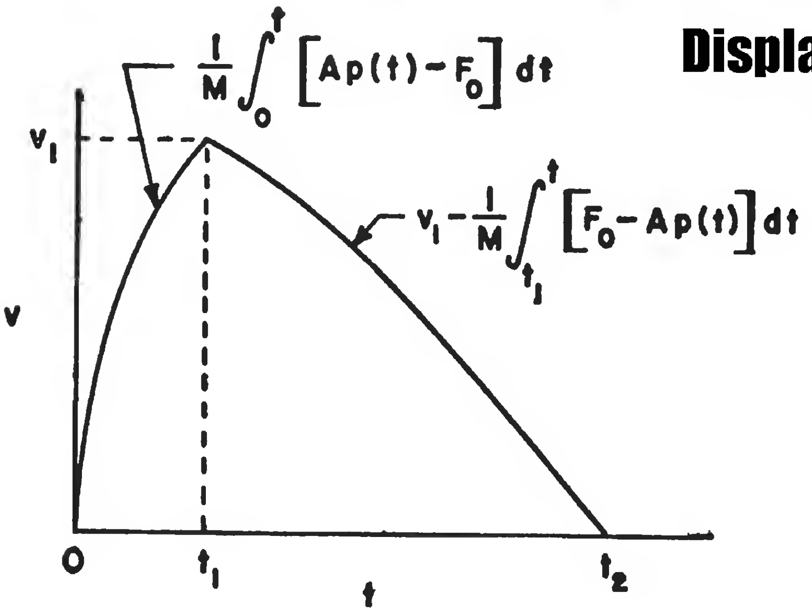
After blast force below that of the resistance of structure, the building ceases to accelerate, and deflection effect is reduced as building returns to original position:

Resisting force, F_0 = Mg + ground contact friction (anchoring of foundations)

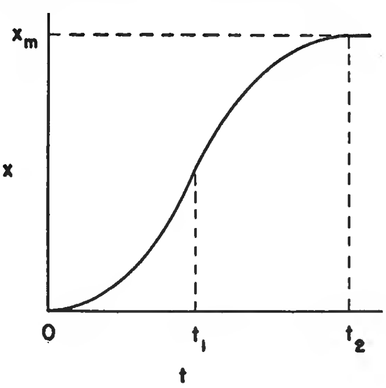


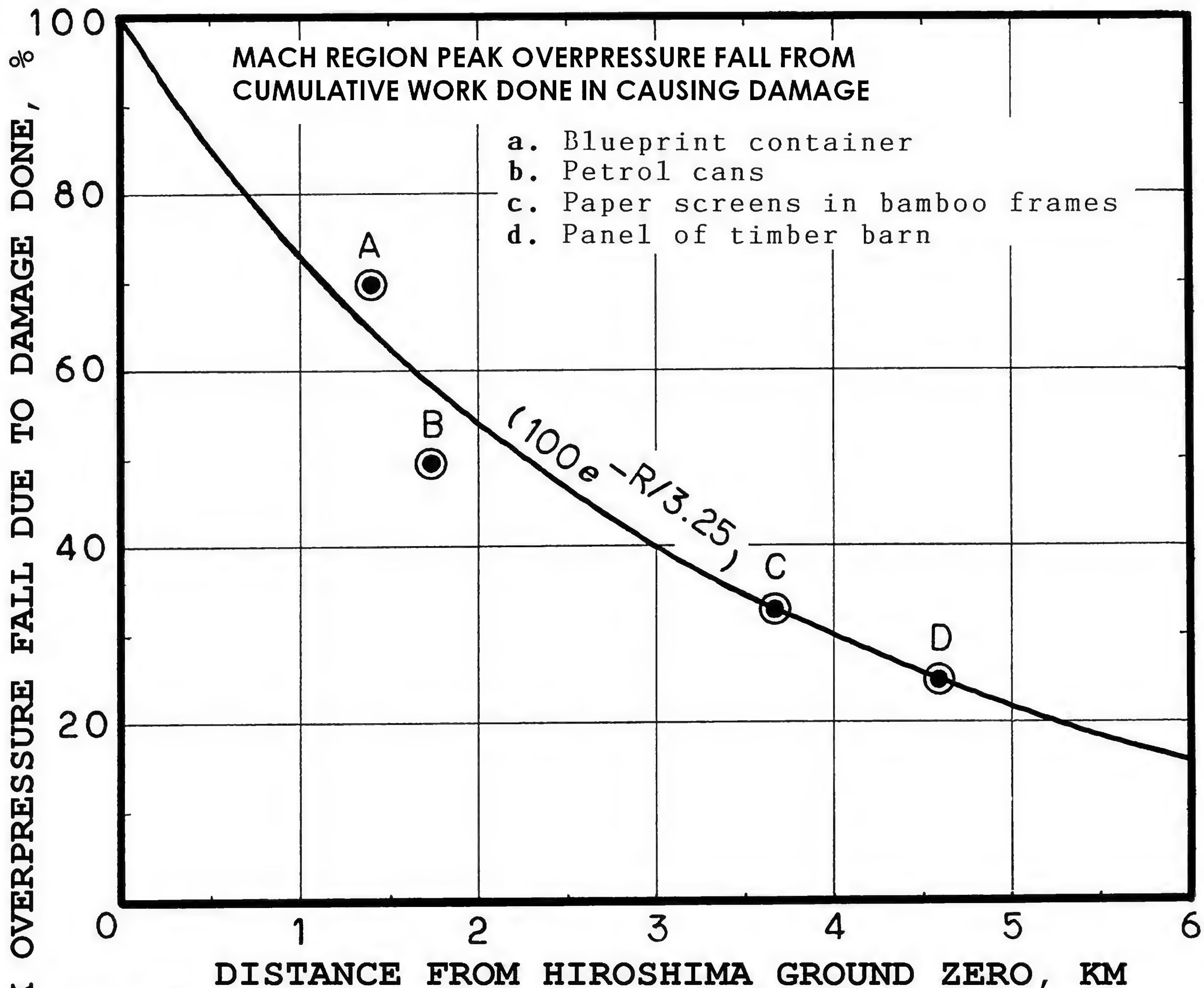
Resisting force decreases if/when walls crack

=> pressure resistance of wall = Mg/A (ignoring ground friction and damage)

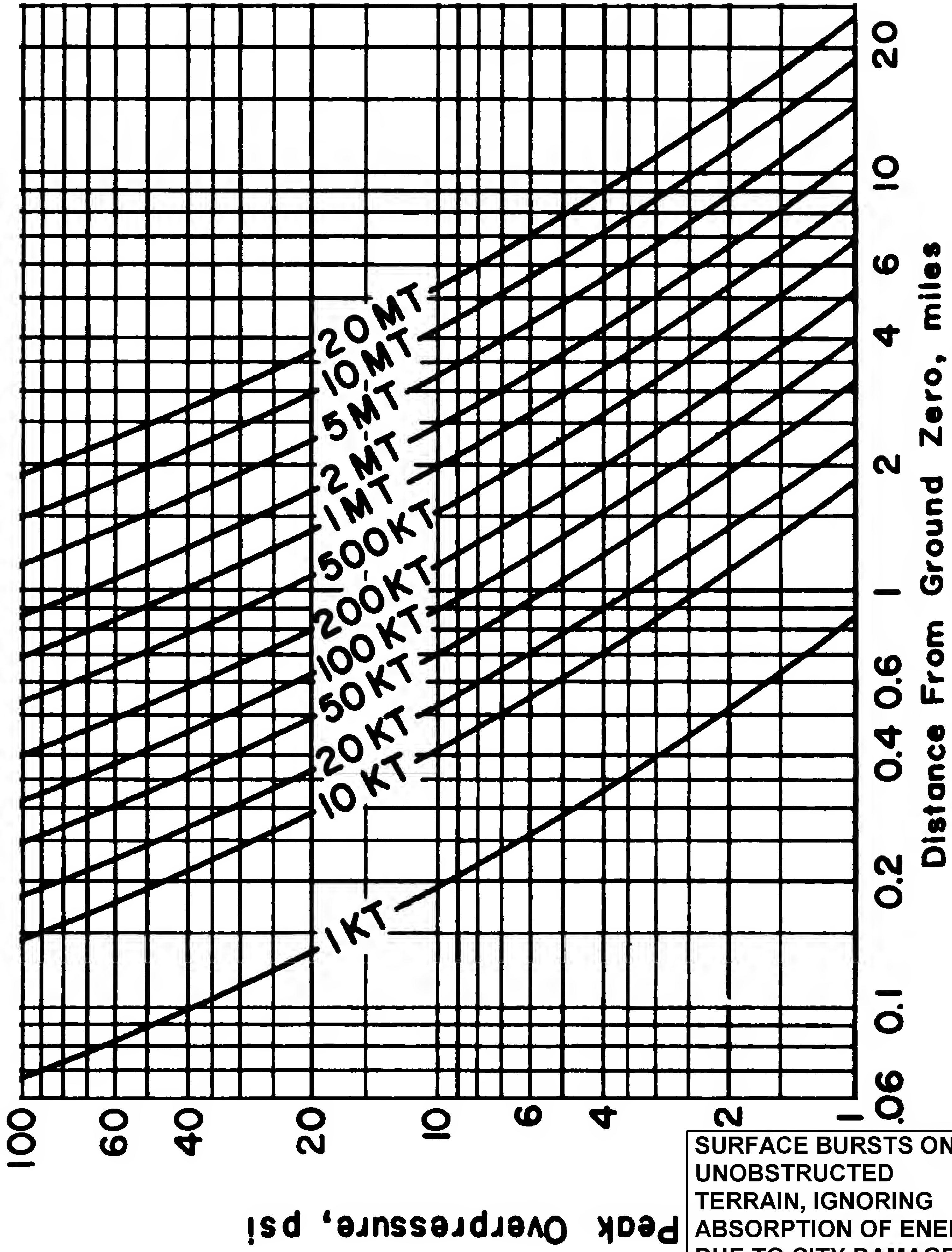


Displacement of centre of mass of building



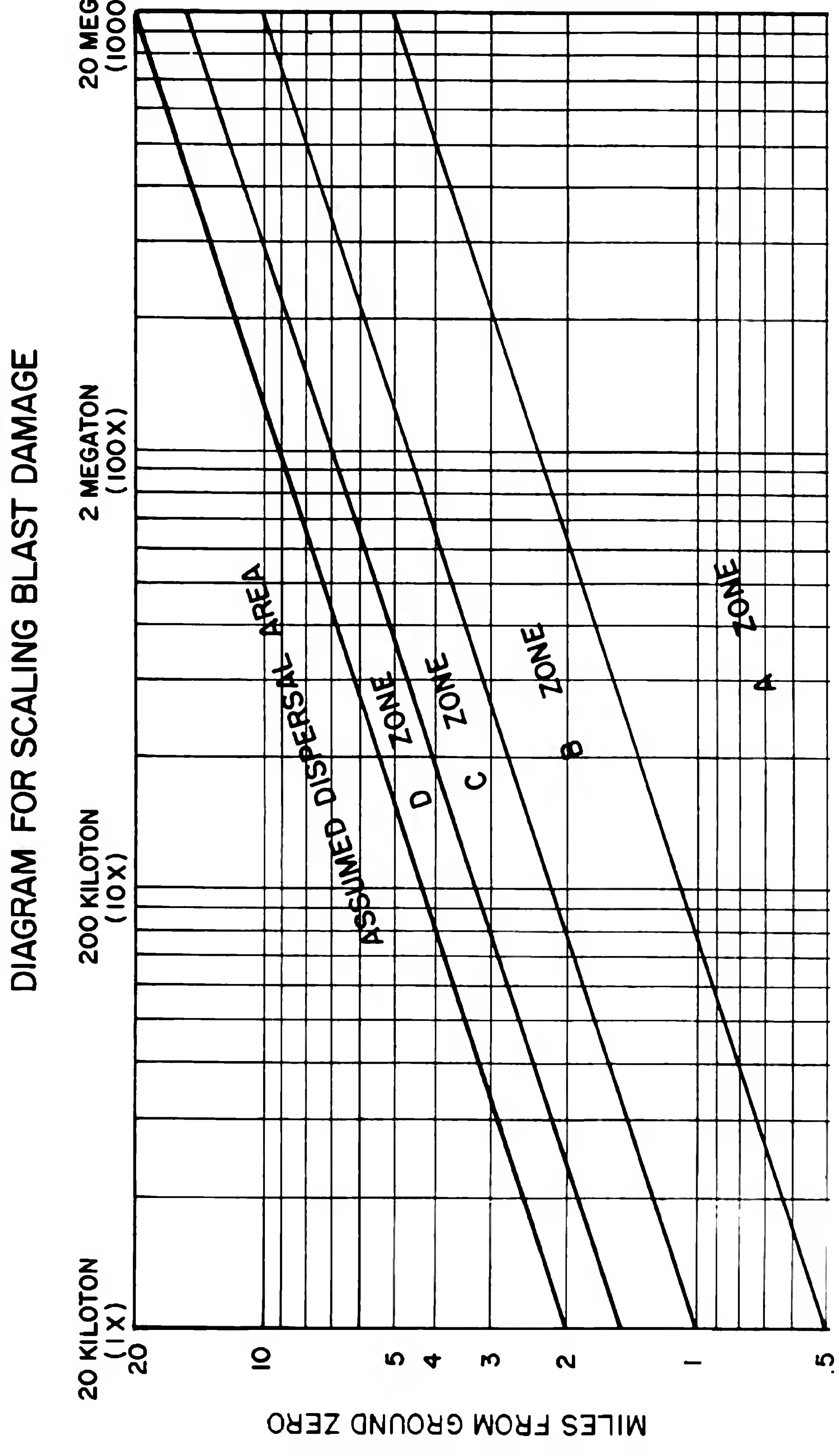


Data from Dr W. G. Penney, et al., 'The Nuclear Explosive Yields at Hiroshima and Nagasaki', Phil. Trans. Roy. Soc., v266 (1970), pp. 357-424.

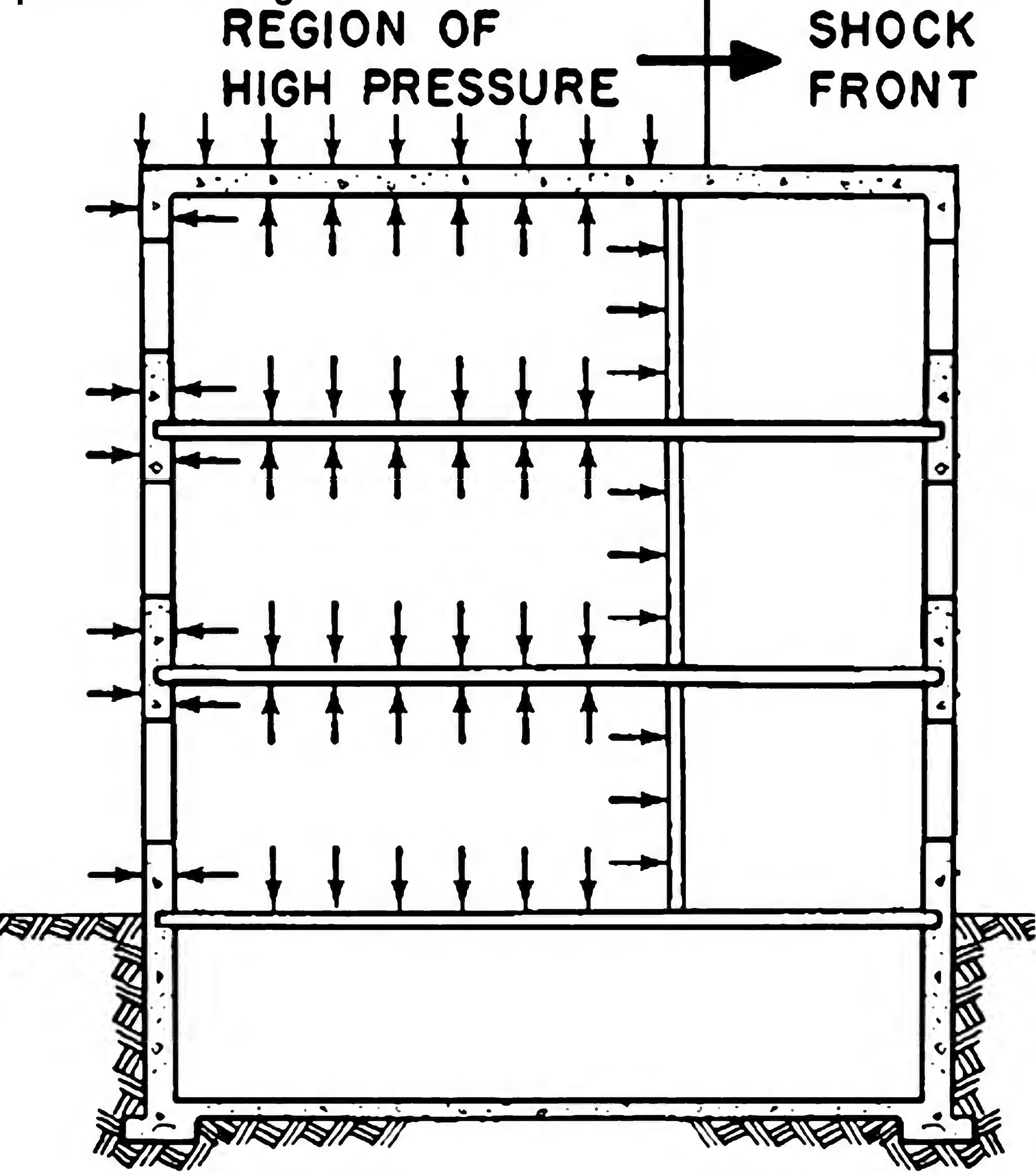


SURFACE BURSTS ON UNOBSTRUCTED TERRAIN, IGNORING ABSORPTION OF ENERGY DUE TO CITY DAMAGE

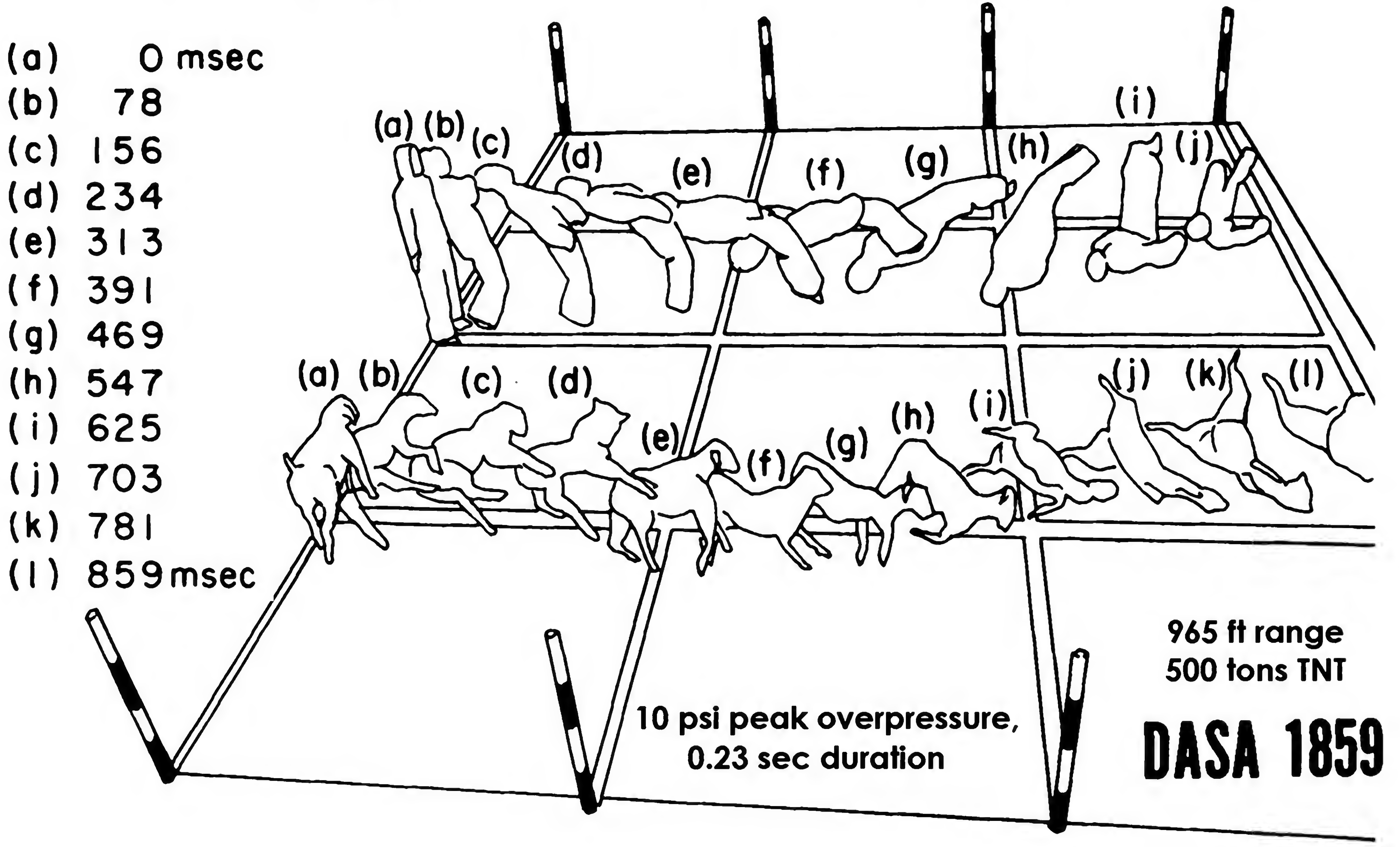
Bomb "power" is NOT proportional to energy:



Rapid equalization of inside and outside pressure for large window areas



Operation Snowball, station 10SB, comparison of human dummy with standing goat (proxy)
peak velocity of initially standing 165 lb dummy = 33.7 ft/sec with 20 ft total displacement
(A U.K. dummy lying prone at 9 psi peak overpressure was unmoved in this test)



INDUSTRIAL PREPAREDNESS AND NUCLEAR WAR SURVIVAL

WEDNESDAY, NOVEMBER 17, 1976

U.S. CONGRESS,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

MR. THOMAS K. JONES

Mr. Jones is the Program and Product Evaluation Manager for the Boeing Aerospace Company. In this capacity he directs analyses and studies of national requirements, evaluates the capabilities of present and potential product lines to satisfy national requirements, and determines the allocation of research budgets to product programs.

From June 1971 thru August 1974, Mr. Jones was employed by the Office of the Secretary of Defense (DDR&E) in support of the Strategic Arms Limitations Talks (SALT). In this assignment, he served as Deputy Director, OSD SALT support group and as Senior Adviser to the OSD member of the U.S. SALT delegation. Through his appointment as a consultant to the Defense Science Board, he is continuing to support the SALT activities.

From 1954 until his employment by the Department of Defense, Mr. Jones was employed by Boeing in a number of design engineering, system engineering, and management assignments. These assignments included work on options to extend the viability of the Minuteman ICBM system, study of strategic tanker systems, analysis of ABM systems, system engineering of manned space systems, and design of strategic bomber systems.

STATEMENT OF MR. THOMAS K. JONES, PROGRAM AND PRODUCT EVALUATION MANAGER, BOEING AEROSPACE COMPANY, ACCOMPANIED BY MR. JOHN R. POTTER, DIRECTOR OF FACILITIES, BOEING COMMERCIAL AIRPLANE COMPANY; AND MR. EDWIN N. YORK, NUCLEAR EFFECTS SPECIALIST

Evacuation, because it distributes people over a comparatively large area, allow them to survive. The United States could, by foregoing half the effectiveness of its arsenal against industrial facilities, spread a lethal level of radioactive fallout over 15 percent of the Soviet Union. However, the evacuees will dig simple shelters to protect against this possibility. The decay rate of that radiation intensity would, within a week, permit the Russians to be out of their shelters for at least an 8-hour workday in 97 percent of their territory.

The Soviet civil defense manuals also provide for a number of ways to protect the critical production machinery within the factories. A book written by A. A. Gromov, hero of Socialist labor and director of the First State Ball Bearing Plant, outlines how these protective methods are being applied to his factory.

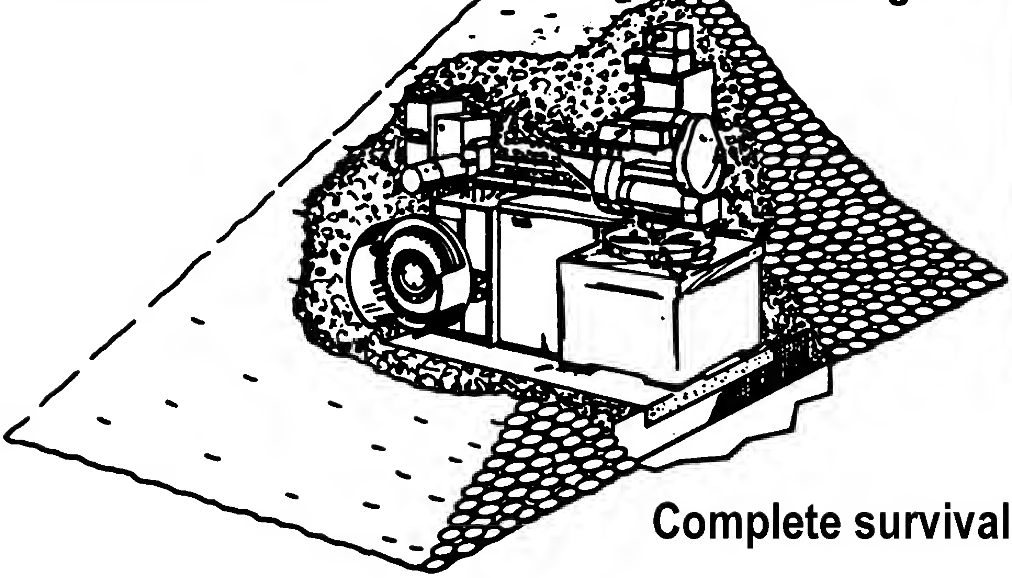
A gas-powered minibike was successfully protected against a blast pressure of 600 pounds per square inch, and a soil heave of 1½ feet; after the test, it was dug out, started and driven away.

In brief, the results of this test indicate that industrial machines, if properly protected, can survive within a few hundred feet from a 40 kiloton nuclear blast, or 2,000 feet from a 1 megaton.

These protective measures, if applied to the Seattle-Tacoma-Everett metropolitan area, could permit resumption of some production operations as early as 4 to 12 weeks after a nuclear attack, depending on the level of radiation intensity.

Protected 5-axis mill

Boeing test



Complete survival

600 psi blast protection for a minibike at .5 kt TNT "Dice Throw" 6 Oct 1976

Dirt filled bags protecting USSR machinery from nuclear war

Civil Defense of an Industrial Installation, A. A. Gromov

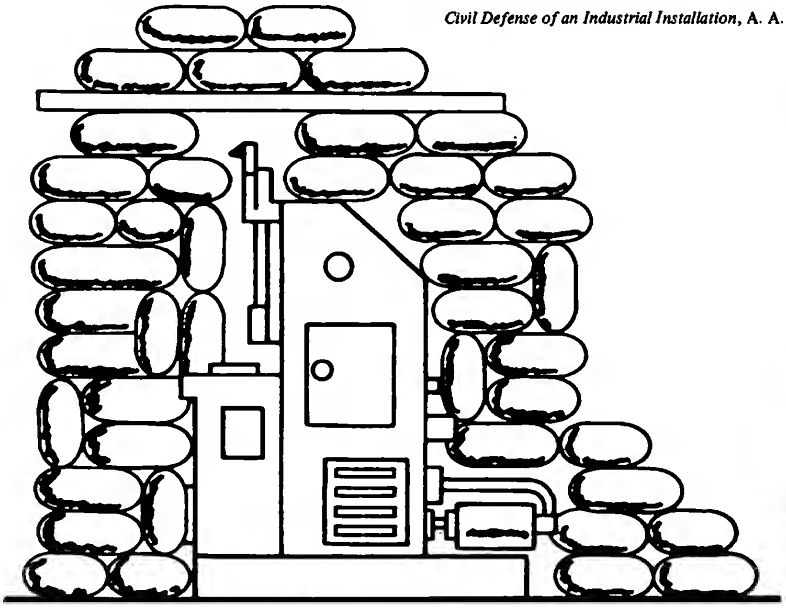


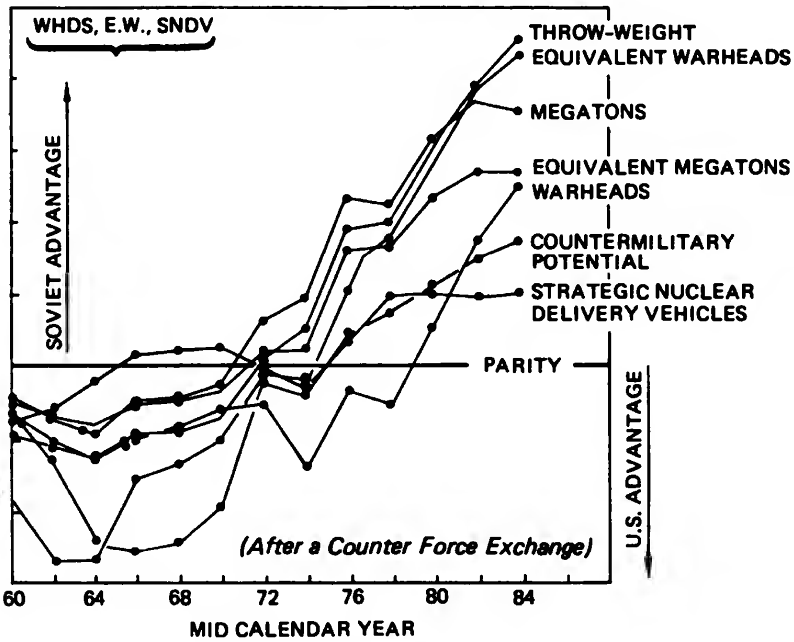
Рис. 2. Вариант консервации

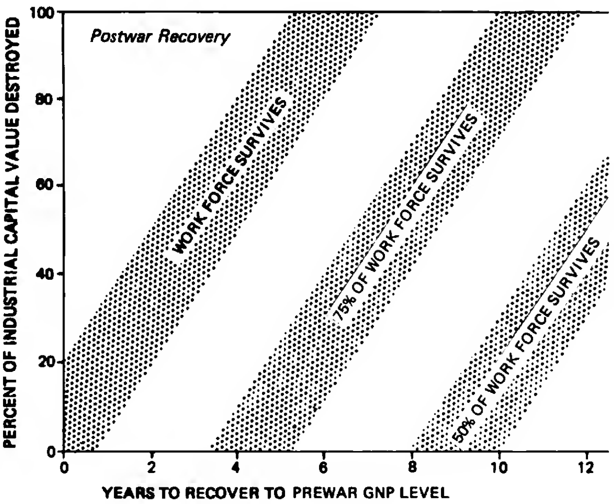
Расход материалов: мешки — 180; брус 60×200 — 20 пог. м; пленка полиэтиленовая — 25 м².

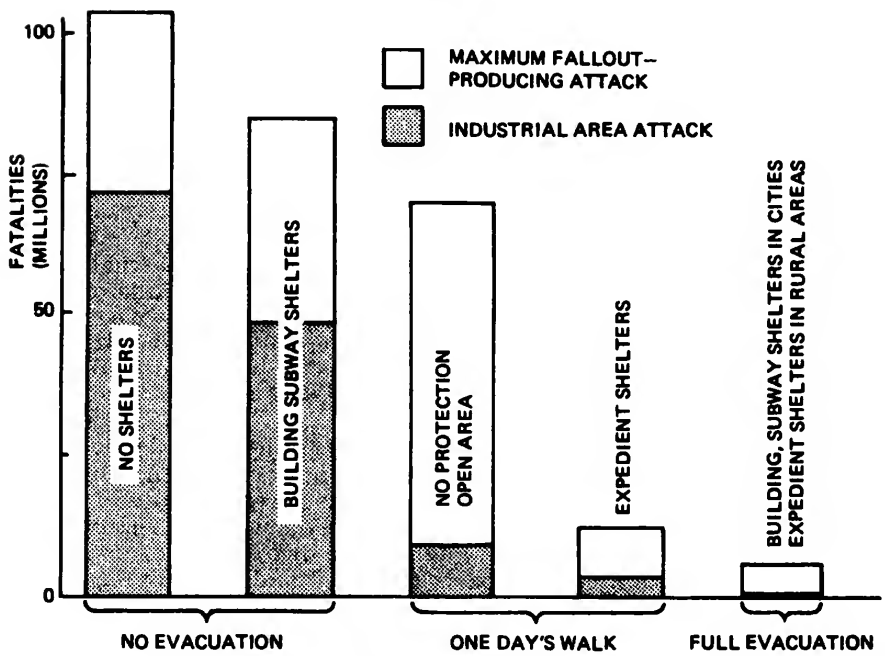
Затрата рабочей силы: насыпка мешков песком, подноска, укладка — 58 чел/час; бригадой в 8 человек при 10-часовой смене работа выполняется за 5,3 часа

D180-20236-1

Figure A-3. Comparison of Alternative Indices of Capability







Soviet population fatalities (surviving U.S. Strategic Forces).

After World War II, public attention was focused almost exclusively on the awesome destructive power of nuclear weapons. As a result, the industrial recovery of bombed cities such as Hiroshima went unnoticed. However, the fact that industry can and will recover from even nuclear devastation is evident from the published findings of the U.S. Strategic Bombing Survey of Hiroshima. The day after the explosion, bridges into downtown Hiroshima were open to traffic, and electric service was restored in some areas. On the second day, trains were again operating. By the third day, some streetcar lines resumed service. Within 9 days, telephone service was restored to the city center. In the outlying areas of the city, water, sewer, and gas services were never interrupted. When the U.S. survey team arrived 2 months after the explosion, the survivors were starting to erect dwellings on their original homesites.[5]

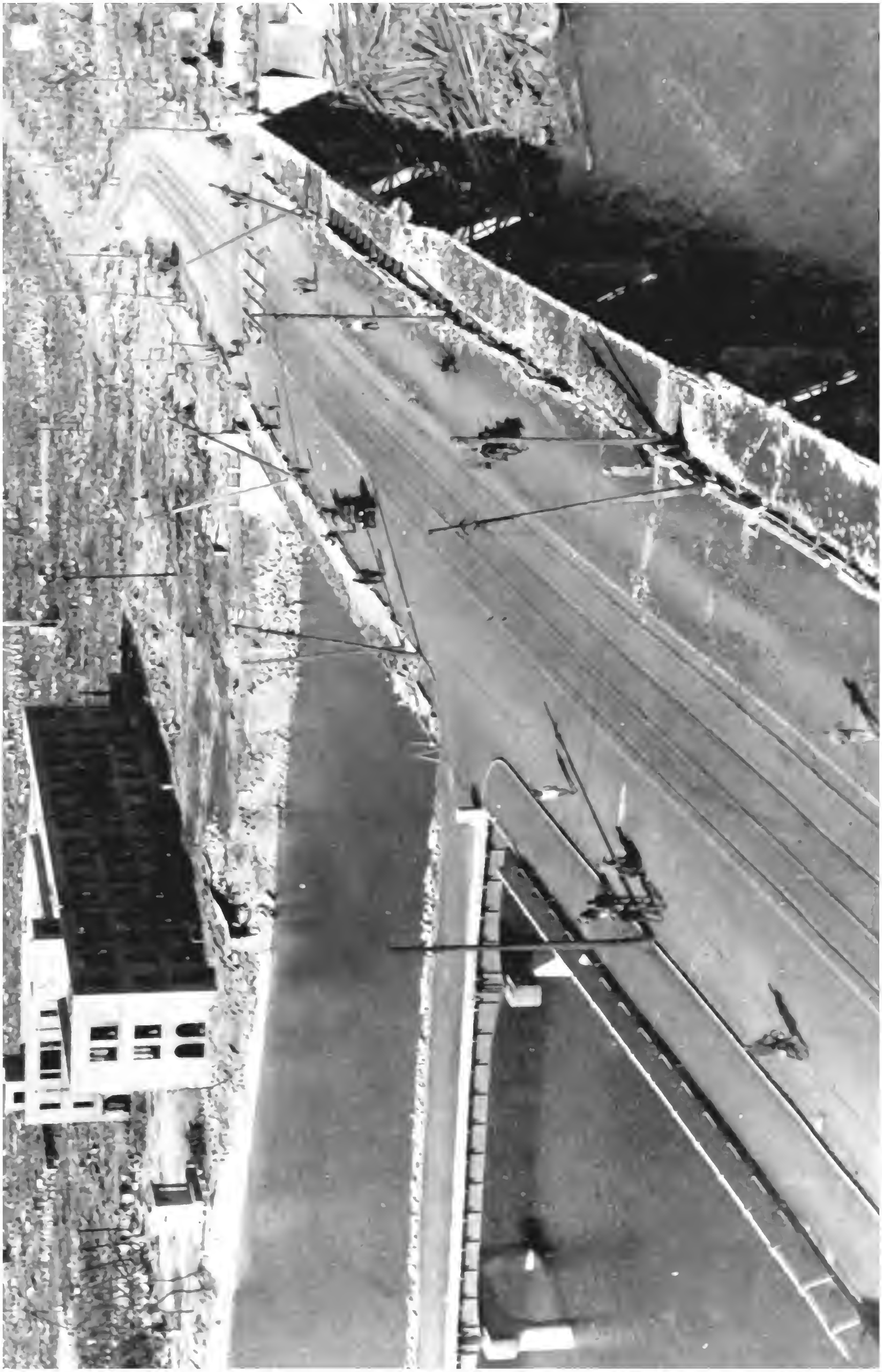
The main Messerschmitt plant at Augsburg was destroyed by over 500 tons of bombs. Thirty buildings and 70% of stored material were destroyed, but only one-third of the machine tools were damaged. Hence, production capacity was reduced by only 35%, and the plant was back in full production in little over 1 month.[6]

The Russians have themselves demonstrated that industrial buildings are not essential to continued production. To protect their aviation industry from German bomber attacks, the Soviets in 1941 used railroad cars to relocate approximately 1,523 industrial enterprises, including 1,360 large war plants, to the Trans-Volga, Urals, Eastern Siberia, and to Kazakhstan and Central Asia. This relocation involved 85% of the entire aviation industry. At many sites, resumption of production began even before temporary facilities were constructed. Machines were set up on temporary platforms in the open, and work was accomplished in weather that reached -40 degrees. Within a year, production rates exceeded the highest rates that had been achieved prior to the relocation.[7]

In order for Americans to judge the true position of the U.S. in a future nuclear confrontation, it is first necessary to establish some perspective as to how damaging a U.S. nuclear retaliatory strike might be to Soviet targets. Briefly summarized, the U.S./USSR survival capabilities are as follows. Given a first strike by the USSR, the U.S. would have on the order of half of its nuclear arsenal (ICBMs, SLBMs, and bombers) surviving. If these weapons were programmed to achieve maximum destruction of industrial targets, the entire U.S. surviving inventory could destroy unprotected people in, at most, 3% of Soviet territory. If the people were protected by simple, foxhole-type shelters, the lethal area that could be imposed by the U.S. surviving arsenal would be reduced to one-third of 1% of the Soviet land mass.[†]

[†]The calculations from which these figures are extracted have been furnished to the Committee at a higher classification.

Aioi Bridge, Hiroshima aiming point, survived



Intersection of Bridge 23 (Left) and Bridge 24 (Right). All Damage From Blast Effects. Bridge 23 (860 Feet to Gz, 2,170 Feet to Az). Bridge 24 (1,000 Feet to Gz, 2,230 Feet to Az).

Hiroshima zero point: damage was caused by charcoal stoves

Some critics argue that the Soviet evacuation and industrial protection plans are not viable because, if an evacuation was started, the U.S. could attack the evacuees before they could be fully dispersed. Such an argument is contrary to the U.S. objective of deterrence. It would be illogical for the United States to be in a position in which, to preserve the viability of its doctrine to deter war, its only recourse would be to preemptively attack the Soviet Union and accept the subsequent destruction of the United States.

The growing Soviet defensive and offensive superiority will most likely result not in nuclear war, but rather force the U.S. to make costly concessions to avoid nuclear war. In a future confrontation, should the Soviets execute their civil defense plans, the consequences to the U.S. of escalation to nuclear war would be disastrous, while the consequences might be tolerable to the Soviet Union. It is believed that the USSR could recover within no more than 2 to 4 years whereas the U.S. could not recover in less than 12 years. In such a condition, the so-called "balance of terror" would no longer be balanced.

Present Soviet civil defense capabilities require that the United States make some important policy decisions. One course of action would be to adhere to our present doctrine and try to make nuclear war as unthinkable for the Soviet Union as it now is for the United States. Another course would be to try to make nuclear war as survivable for the United States as it now is for the Soviet Union. There may be some middle ground between these two options.

Following the first course would imply an attempt by the U.S. to overpower the Soviet civil defenses. This would require a massive increase in the U.S. nuclear arsenal, or possibly a search for some new terror weapon that if used would really destroy all mankind. The second course would involve increased emphasis on defenses for the United States; probably some combination of air and civil defenses. Such defenses presumably would make nuclear war more thinkable for the U.S. and hence would be objectionable to some. However, unless we can be assured that nuclear war is unthinkable for the Soviet Union, it must be made survivable for the U.S.

. . . a civil defense program will permit the United States to maintain its security for less cost and with less nuclear weaponry than would otherwise be required.

REFERENCES

5. "The Effects of the Atomic Bomb on Hiroshima, Japan," U.S. Strategic Bombing Survey, Physical Damage Division, May 1947.

6. W.F. Craven, *The Army Air Forces in World War II*, Vol. III, University of Chicago Press, 1951, p. 42.

7. "The Relocation of the Soviet Aviation Industry During World War II: A Background Study," prepared by Major Walter Jajko, USAFR, DTS-1, for the Directorate of Soviet Awareness, June 1976.

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Senator PROXMIRE. Well, now, as you may recall, one of the big arguments in finally defeating the ABM was the argument that you could always overcome any defensive measure, at least with respect to the ABM, with a far less expensive offense, in other words, $10 spent in offense would overcome $100 spent in defense, or something like that, roughly in that area.

Are you contending that civil defense wouldn't have anything like that, that it would be cheaper to provide defense in relationship to the offensive cost of overcoming it?

Mr. JONES. Yes, Senator. That is a very important question because it is true, as you have indicated, that the cost leverages against ABM are such that they can be cheaply overcome with offensive forces. Moreover, certain types of civil defenses are also not cost effective. For example, if the United States invested heavily in large population shelters within the cities, we believe it likely that the Soviet Union could overcome those at less cost than it took us to build them.

Some people have brought up the possibility that we would attack the evacuees before they could get away, but the whole deterrence theory is based on the hostage idea. If you blow up the hostage before he gets away, you have no more hostage. Moreover, your adversary is twice as angry at you. Therefore, for the United States to preemptively attack the Soviet evacuees when they start evacuating would be a very suicidal thing to do.

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Senator PROXMIRE. Well, let me just say, what makes me hesitate on this—and I think Congressman Mitchell, too—is that our nuclear arsenal is so colossal, we are told that we have about 15 tons of TNT for every man, woman and child in the world, the equivalent in our nuclear power. The Administration has cut back the budget for civil defense. They haven't increased it; they have cut it back.

I don't know of anybody in the Defense Department—heaven knows they are concerned with the defense of our country; that is their responsibility—who is calling for a big, vigorous civil defense effort.

Is there anyone in the Defense Department that supports your view, any group? Or any defense experts outside the Defense Department who feels that we should consider engaging in this kind of ambitious and very expensive civil defense effort?

Mr. JONES. Yes, sir, I believe that there are a number of people who are concerned in the Department of Defense. They are concerned because they see an imbalance in vulnerability that could lead to a serious problem—despite the size of our nuclear arsenal. Regardless of how many tons of TNT we have for each man, woman and child, we nonetheless, if you look at how much of the Soviet territory our surviving weapons could damage, it is not much. It is only about 3 percent.

Going back to the previous point, I think a large amount of the Soviet civil defense preparation is multipurpose. It certainly can protect against the Chinese. It certainly can also protect against the United States.

I thought it was significant that the Soviets accelerated their civil defense preparations at about the time that we were signing the ABM treaty in 1972.

APPENDIX

CIVIL DEFENSE AND THE STRATEGIC BALANCE

Civil defense is not of itself a threatening capability. Both Sweden and Switzerland have extensive and well-prepared civil defense programs. These programs do not threaten either the U.S. or the USSR because neither Sweden nor Switzerland possesses the offensive weaponry to seriously damage either of the two major powers. For this same reason, the Soviet civil defense preparations, although they date from before World War II, did not in earlier years threaten the United States.

However, in 1972 when the SALT I agreements were signed, it was publicly stated that the United States no longer had nuclear superiority; the forces of the two sides were at approximate parity. Since then, the Soviets have initiated concurrent deployment of four new ICBM models, creating serious concerns in the U.S. as to the trends in the strategic balance.

Paul H. Nitze has suggested that there are three different ways in which the strategic balance can be measured:

1. That which each side has *before* a strike
2. That *surviving* to the United States after an initial counterforce strike by the Soviet side
3. That remaining to each side *after an exchange*

ADDITIONAL QUESTIONS FOR THE RECORD

FOR

T.K. JONES

Question 1.

On what calculations do you base your estimate that 98% of the Soviet population would survive a massive countervalue attack with the entire U.S. arsenal of 8,500 or more nuclear warheads?

Answer

First, our estimate is based not on the "entire U.S. arsenal" but on the weapons that the U.S. could optimistically expect to survive a Soviet first strike.

The Soviet Union was assumed to have no antiballistic missile (ABM) defenses. Soviet air defenses were assumed to have been suppressed even though no U.S. warheads were assumed to be used for this purpose. All U.S. warheads (on SLBMs, bombers, and ICBMs) were assumed to be expended in a retaliatory strike on Soviet urban/industrial areas or on evacuation areas. (This latter assumption is particularly naive since it would leave the United States totally disarmed and leave Soviet military assets largely untouched.)

One fulfillment of this view was the October 1973 Middle East war, where a Soviet threat to intervene caused the United States to restrict deliveries to Israel, thereby bringing about the release of the encircled Egyptian army.

Marshal Grechko's view of the matter was that:

> It was precisely the change in the correlation of forces in favor of socialism and the process of the relaxation of tension taking place on this basis which prevented the dangerous eruption of the war in the Near East from assuming dimensions threatening universal peace.

In Angola, the United States backed down with minimum protest and no effective counteractions. The Soviet leaders could logically view these events as an emerging tendency of the United States to back down in confrontations. Once such a pattern of concessions is established, it is increasingly difficult to halt the process.

As the correlation of forces shifts further in favor of the Soviet Union, it is not unrealistic to believe that the United States would be willing to back down in confrontations even more important than Angola and the Middle East. By 1978, the Soviet Union will have gained a "war-winning" capability comparable to that which the United States held in 1962 during the Cuban missile crisis. (See Figure A-3 of the study report.) The Soviets believe we have rational leadership and that the U.S. leadership, when placed at a major disadvantage, as the Soviets themselves were in 1962, can be forced to acquiesce to Soviets demands in future confrontations.

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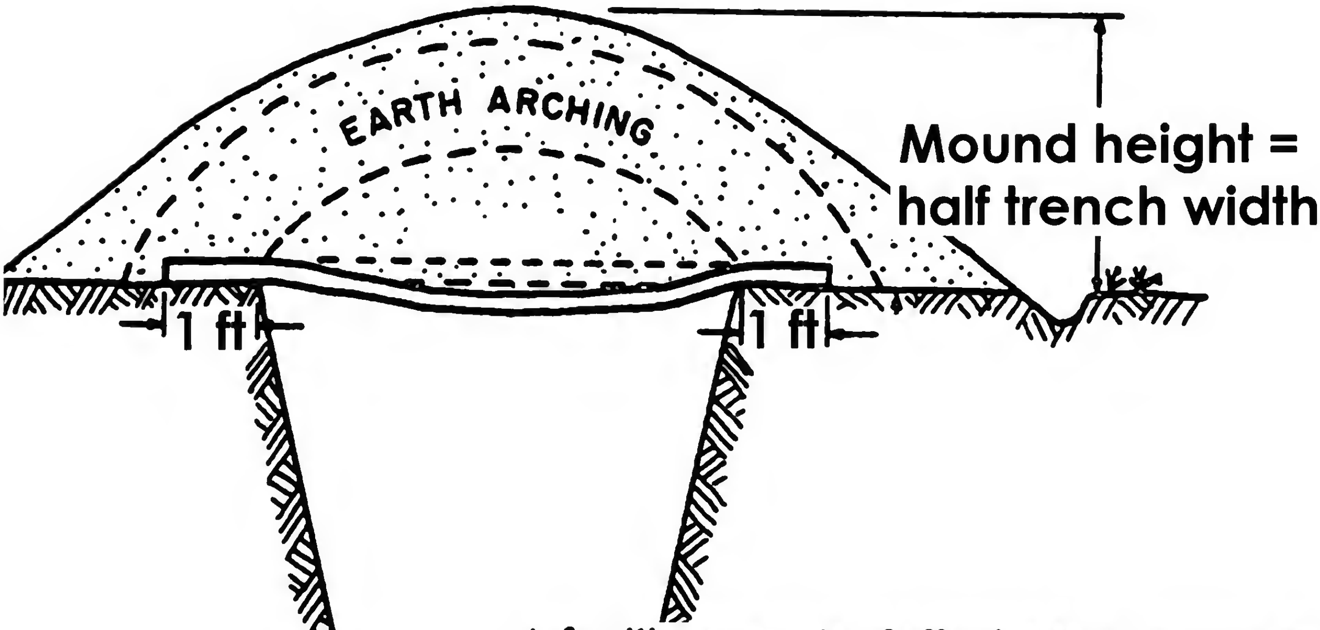
Question 24.

What evidence is available to indicate that the Soviet industrial defense measures have been implemented throughout the U.S.S.R. and are not merely "pilot" or "demonstration" programs at a few facilities?

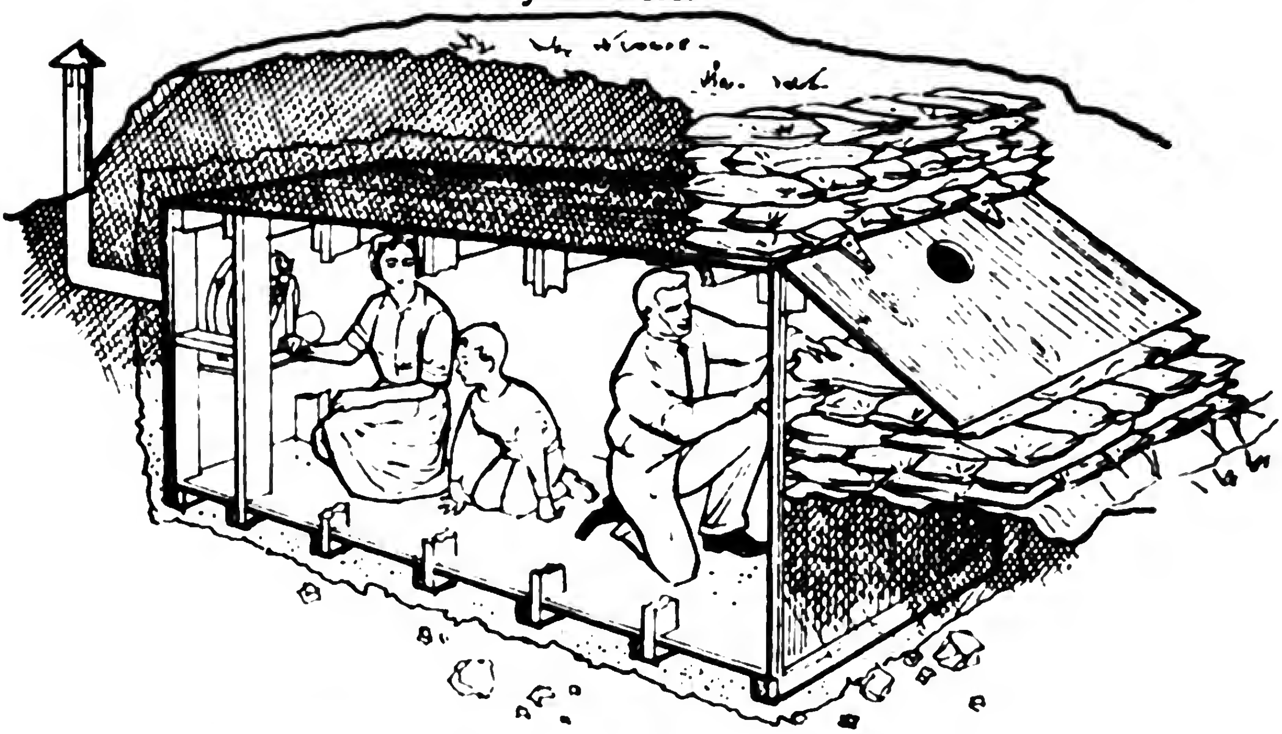
Answer

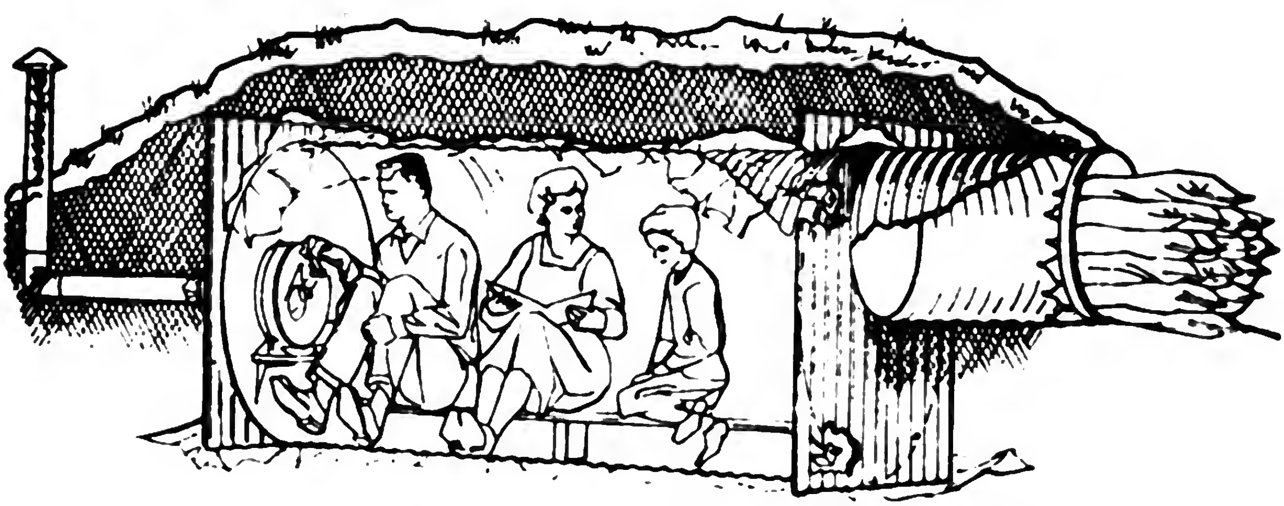
Soviet civil defense literature and commentary by Soviet civil defense spokesmen over the past several years indicate this is not the case. Soviet newspapers and journals, especially the civil defense monthly, VOY ZNAN (circulation in excess of 300,000), refer to industrial defense measures underway at a broad variety of industry installations. Books such as Civil Defense of an Industrial Installation (2 editions totalling 500,000 copies) indicate nationwide programs.

EARTH ARCHING USED TO STRENGTHEN SHELTERS



A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.

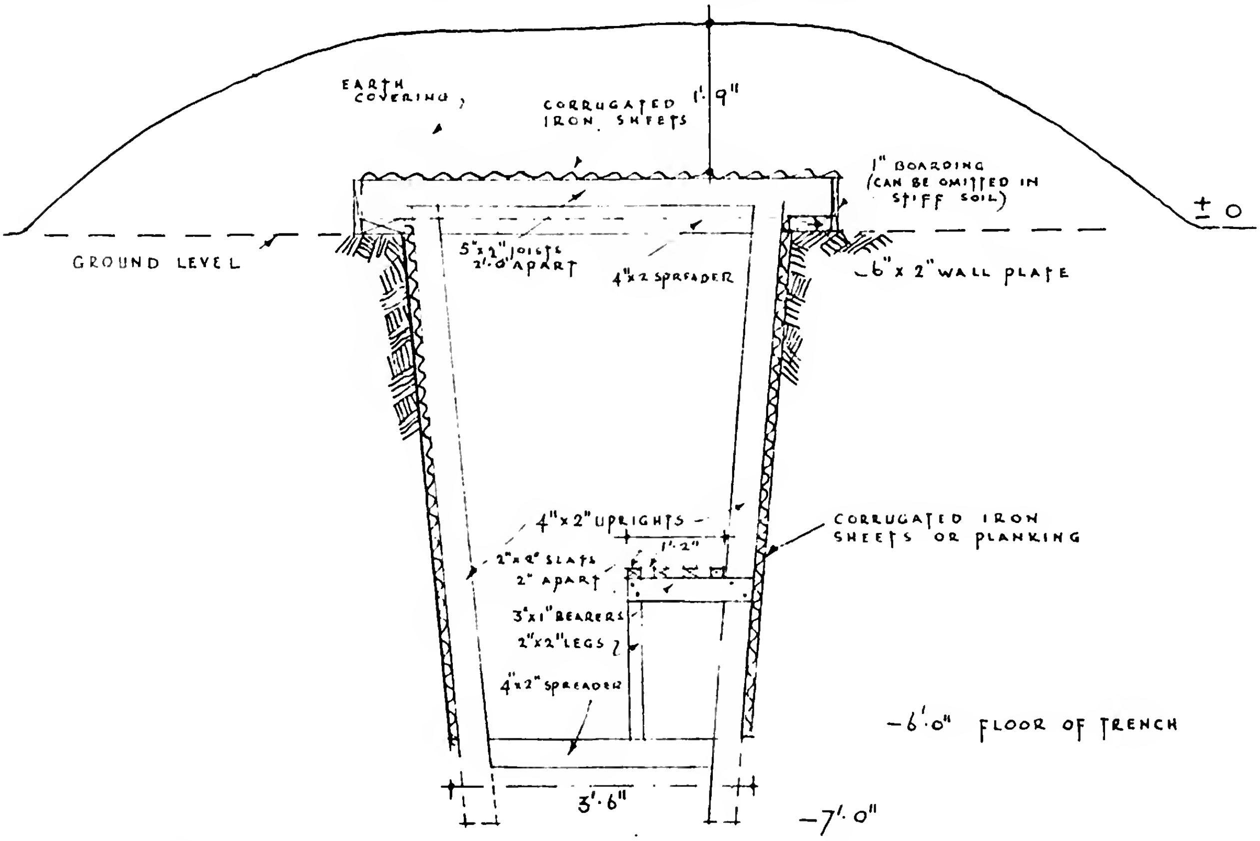




UK National Archives: HO 45 / 17589 / 3 Garden trench shelter 1938-9

GARDEN TRENCH SHELTER

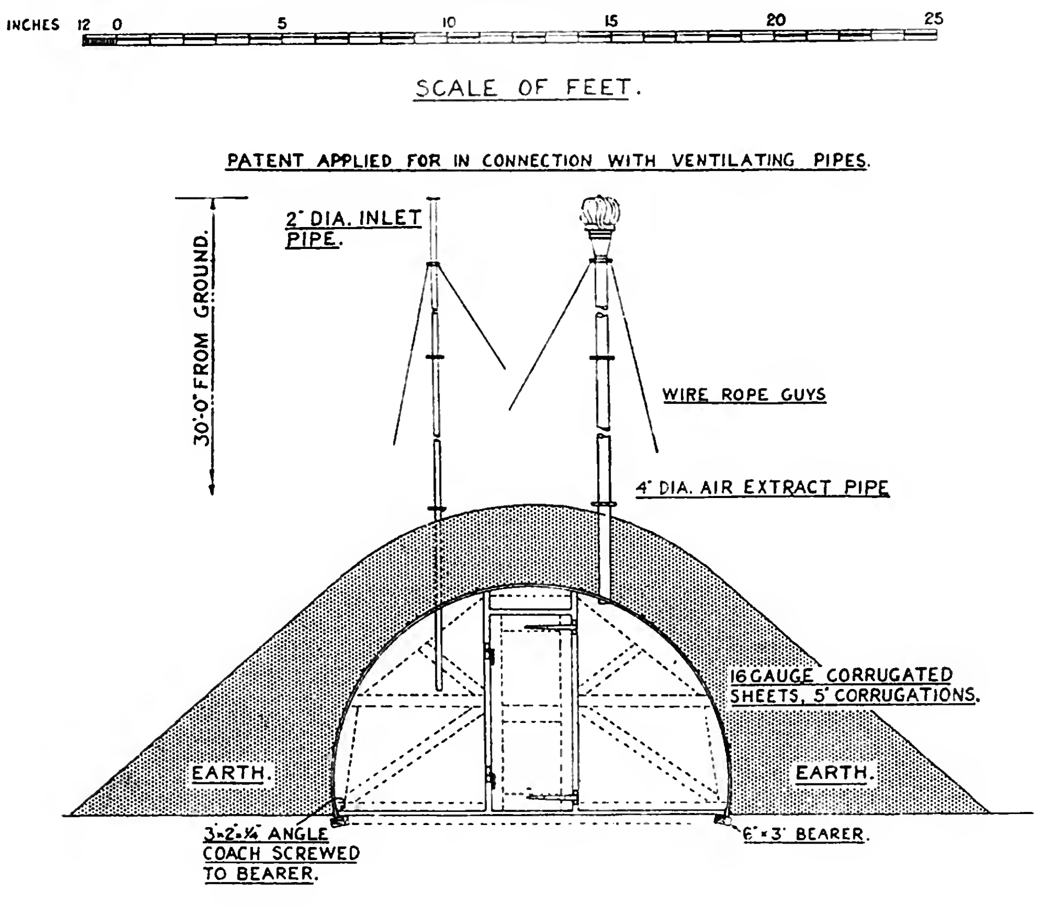
HOME OFFICE A.R.P. DEPARTMENT



National Archives: HO45 / 17590 Nissen corrugated steel shelter 1938

THE NISSEN AIR RAID SHELTER

CAPACITY· 50 PERSONS.



ORNL-5037

Nuclear War Survival Skills

Cresson H. Kearny

[Note: Kearny was inspired to write this by the USSR manuals like "Antiradiation shelters in Urban Areas", 1972, English translation: Oak Ridge Nat. Lab., ORNL-TR-2745.]

Oak Ridge National Laboratory
Oak Ridge, Tennessee

September 1979

Summary

Underlying the advocacy of Americans' learning these down-to-earth survival skills is the belief that if one prepares for the worst, the worst is less likely to happen. Effective American civil defense preparations would reduce the probability of nuclear blackmail and war. Yet in our world of increasing dangers, it is significant that the United States spends much less per capita on civil defense than many other countries. The United States' annual funding is about 50 cents per capita, whereas Switzerland spends almost $11 and, most importantly, the Soviet Union spends approximately $20.

In the first chapter the myths and facts about the consequences of a massive nuclear attack are discussed. As devastating as such an attack would be, with adequate civil defense preparations and timely warning much of the population could survive.

One appendix of the handbook gives detailed, field-tested instructions for building six types of earth-covered expedient fallout shelters, with criteria to guide the choice of which shelter to build. The design features of several types of expedient blast shelters are described in another appendix. Two others contain instructions for making an efficient shelter-ventilating pump and a homemade fallout meter that is accurate and dependable. Both of these essentials can be made with inexpensive materials found in most households. Drawings are used extensively, as are photographs of people actually building and living in the various shelters.

This first-of-its-kind report is primarily a compilation and summary of civil defense measures and inventions developed at ORNL over the past 14 years and field-tested in six states, from Florida to Utah.

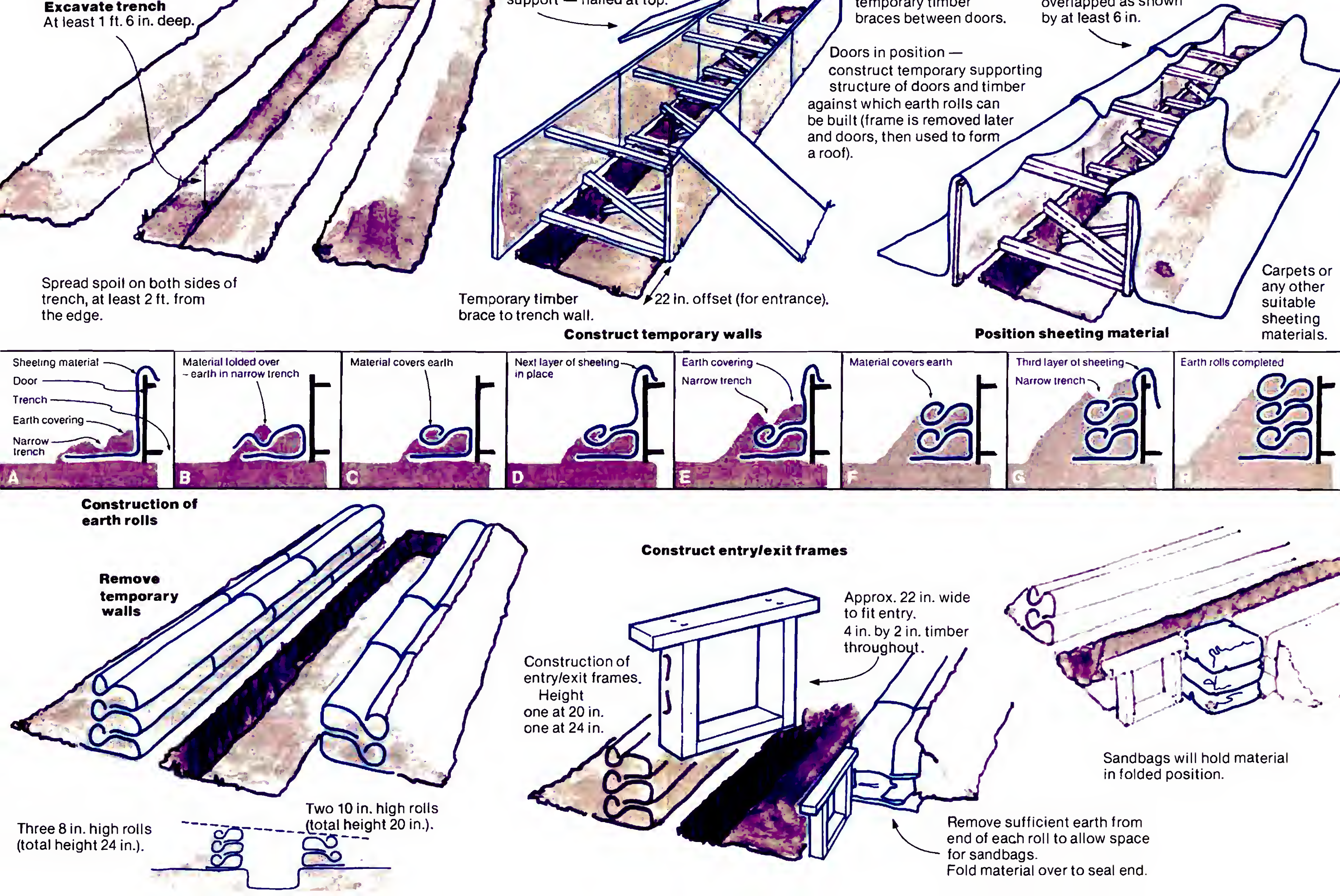
- **Myth:** Fallout radiation from a nuclear war would poison the air and all parts of the environment. It would kill everyone. (This is the demoralizing message of *On the Beach* and many similar pseudo-scientific books and articles.)
- **Myth:** A heavy nuclear attack would set practically everything on fire, causing "firestorms"
- **Myth:** In the worst-hit parts of Hiroshima and Nagasaki where all buildings were demolished, everyone was killed by blast, radiation, or fire.
- **Myth:** Because some modern H-bombs are over 1000 times as powerful as the A-bomb that destroyed most of Hiroshima, these H-bombs are 1000 times as deadly and destructive.

These exaggerations have become demoralizing myths, believed by millions of Americans.

HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage

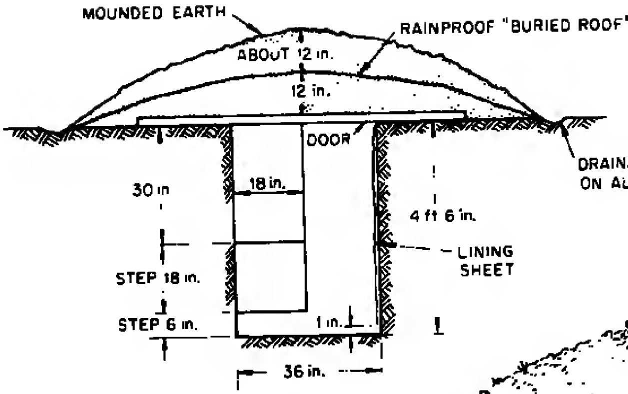
NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage

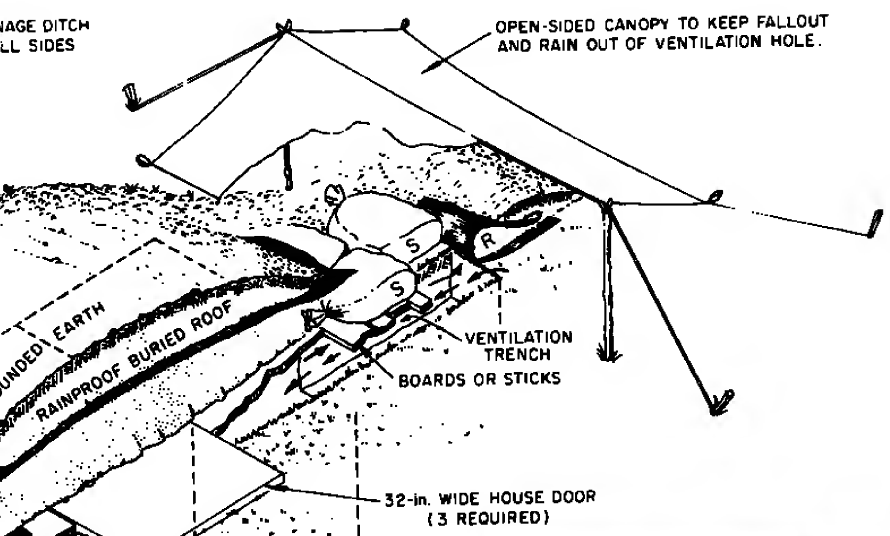
Type 1a

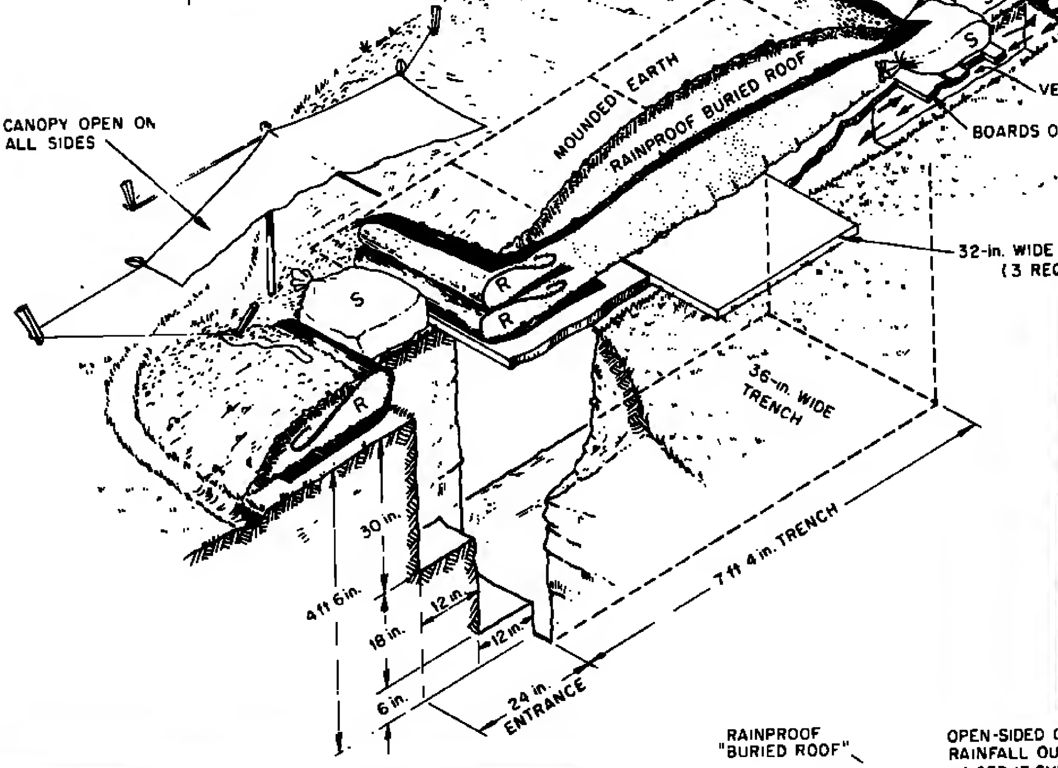


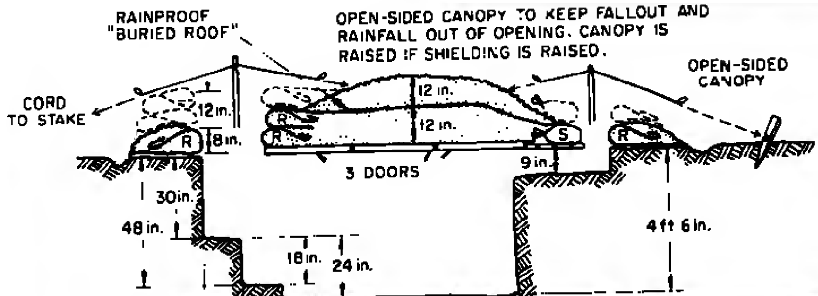
Excavate trench
At least 1 ft. 6 in. deep.
Spread spoil on both sides of trench, at least 2 ft. from the edge.
Door used as temporary support — nailed at top.
40 in. by 4 in. by 2 in. temporary timber braces between doors.
Doors in position — construct temporary supporting structure of doors and timber against which earth rolls can be built (frame is removed later and doors, then used to form a roof).
Temporary timber brace to trench wall.
22 in. offset (for entrance).
Construct temporary walls
Material should be overlapped as shown by at least 6 in.
Carpets or any other suitable sheeting materials.
Position sheeting material
Sheeting material
Door
Trench
Earth covering
Narrow trench
A
Material folded over - earth in narrow trench
B
Material covers earth
C
Next layer of sheeting in place
D
Earth covering
Narrow trench
E
Material covers earth
F
Third layer of sheeting
Narrow trench
G
Earth rolls completed
Construction of earth rolls
Remove temporary walls
Three 8 in. high rolls (total height 24 in.).
Two 10 in. high rolls (total height 20 in.).
Construct entry/exit frames
Construction of entry/exit frames. Height one at 20 in. one at 24 in.
Approx. 22 in. wide to fit entry.
4 in. by 2 in. timber throughout.
Sandbags will hold material in folded position.
Remove sufficient earth from end of each roll to allow space for sandbags.
Fold material over to seal end.

ORNL-4979 **Door-over-trench shelter.**









PREVENTION OF THYROID DAMAGE FROM RADIOACTIVE IODINES

An extremely small and inexpensive daily dose of the preferred non-radioactive potassium salt, potassium iodide (KI), if taken 1/2 hour to 1 day before exposure to radioactive iodine, will reduce later absorption of radioactive iodine by the thyroid to only about 1% of what the absorption would be without this preventive measure. Extensive experimentation and study have led to the Federal Drug Administration's approval of 130-milligram (130-mg) tablets for this preventive (prophylactic) use only. A 130-mg dose provides the same daily amount of iodine as does each tablet that English authorities for years have placed in the hands of the police near nuclear power plants, for distribution to the surrounding population in the very unlikely event of a major nuclear accident. It is quite likely that a similar-sized dose is in the Russian "individual, standard first-aid packet." According to a comprehensive Soviet 1969 civil defense handbook, this first-aid packet contains "anti-radiation tablets and anti-vomiting tablets (potassium iodide and etaperain)."

The Effects of

Nuclear Weapons

Samuel Glasstone

Editor

Prepared by the

UNITED STATES DEPARTMENT OF DEFENSE

Published by the

UNITED STATES ATOMIC ENERGY COMMISSION

June 1957

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $2.00 (paper bound)

Foreword

This handbook, prepared by the Armed Forces Special Weapons Project of the Department of Defense in coordination with other cognizant government agencies and published by the United States Atomic Energy Commission, is a comprehensive summary of current knowledge on the effects of nuclear weapons. The effects information contained herein is calculated for yields up to 20 megatons and the scaling laws for hypothetically extending the calculations beyond this limit are given. The figure of 20 megatons however is not to be taken as an indication of capabilities or developments.

CHARLES E. WILSON
Secretary of Defense

LEWIS L. STRAUSS
Chairman
Atomic Energy Commission

WRONG!, OMITS:
(1) PRECURSOR
(2) HIROSHIMA FIRESTORM MECHANISM (USSBS REPORT 92, V2, 1947)
(3) HIROSHIMA CASUALTY RATES IN DIFFERENT TYPES OF STRUCTURES (CNP-3041, 1951)
(4) EMP EFFECTS

THE FEDERAL CIVIL DEFENSE ADMINISTRATION commends this publication as the definitive source of information on the effects of nuclear weapons for the use of organizations engaged in Civil Defense activities. Its detailed treatment of the physical phenomena associated with nuclear explosions provides the necessary technical background for development of countermeasures against all nuclear effects of Civil Defense interest.

VAL PETERSON
Administrator
Federal Civil Defense Administration

Acknowledgment

At the request of the Atomic Energy Commission, the Armed Forces Special Weapons Project prepared this book with the assistance of the Commission. Dr. Samuel Glasstone was responsible for the compiling, writing, and editing and, largely, for its successful completion.

Assistance in the preparation and review of the book was provided by individuals associated with the Atomic Energy Commission, the Department of Defense, the Federal Civil Defense Administration, and their contractors.

PROBLEM: DR SAMUEL GLASSTONE USED A LOT OF WORDS IN ALL HIS TEXTBOOKS, HENCE THE FEELING THAT AN OVERLOAD OF TECHNICAL DETAILS INCREASED THE "NOISE LEVEL" AND PUT-OFF WIDESPREAD UNDERSTANDING OF KEY FACTS FOR SURVIVAL.

WRONG: TESTS OVER UNOBSTRUCTED OCEAN OR UNOBSTRUCTED DESERT MAXIMISE & EXAGGERATE EFFECTS

Preface

OBTAINED IN REALITY (CITY SKYLINES!)

When "The Effects of Atomic Weapons" was first issued, in 1950, the explosive energies of the atomic bombs known at that time were equivalent to some thousands of tons of TNT. The descriptions of atomic explosions and their effects were therefore based on a so-called "nominal" bomb with an energy release equivalent to that of 20,000 tons (or 20 kilotons) of TNT. It is no longer possible to describe the effects in terms of a single nominal bomb. An essentially new presentation of weapons effects has consequently become necessary and is titled "The Effects of Nuclear Weapons."

The main purpose of this new handbook is to describe, within the limitations set by national security, the basic phenomena and the most recent data concerning the effects associated with explosions of nuclear weapons. The information has been obtained from observations made following the wartime nuclear bombings in Japan and at the tests carried out at the Eniwetok Proving Grounds and the Nevada Test Site, as well as from experiments with conventional high explosives and mathematical calculations. Tests have provided much important data on weapons effects; nevertheless, a distinction should be made between the consequences of such tests, when all conceivable precautions are taken to eliminate hazards to life and property, and of the consequences of the use of nuclear weapons in warfare, when the efforts of an enemy would be devoted to causing the maximum destruction and casualties. It is for use in planning against possible nuclear attack that this volume is intended.

The major portion of the book consists of a statement of the facts relating to nuclear explosions and of an objective, scientific analysis of these facts. In the final chapter some general conclusions are presented upon which protective measures may be based. It should be emphasized, however, that only the principles of protection are discussed; there is no intention of recommending the adoption of particular procedures. The responsibility for making and implementing policy with regard to such matters as protective construction, shelters, and evacuation lies with the Federal Civil Defense Administration and other United States Government agencies. The information presented in this book should prove useful to these agencies in plan-

ning defensive measures for the protection of civilian lives and property.

The phenomena of blast, shock, and various radiations associated with nuclear explosions are very complex. It is inevitable, therefore, that the description of these phenomena and their related effects should be somewhat technical in nature. However, this book has been organized in a manner that will serve the widest possible audience. With this end in view, each chapter, except Chapters IV, X, and XII, is in two parts: the first consists of a general treatment of a particular topic in a less technical manner, whereas the second part contains the more technical aspects. The material is so arranged that no loss of continuity will result to the reader from the omission of any or all of these more technical sections. It is hoped that this format will permit the general reader to obtain a good understanding of each subject without the necessity for coping with technical material with which he may not be concerned. On the other hand, the technical material is available for specialists, as for example architects engineers, medical practitioners, and others, who may have need for such details in their work connected with defense planning.

SAMUEL GLASSTONE

JUNE 1957 "Effects of Nuclear weapons"

Ductility

3.73 The term ductility refers to the ability of a material or structure to absorb energy inelastically without failure; in other words, the greater the ductility, the greater the resistance to failure. Materials which are brittle have poor ductility and fail easily.

3.74 There are two main aspects of ductility to be considered. When a force (or load) is applied to a material so as to deform it, as is the case in a nuclear explosion, for example, the initial deformation is said to be "elastic." Provided it is still in the elastic range, the material will recover its original form when the loading is removed. However, if the "stress" produced by the load is sufficiently great, the material passes into the "plastic" range. In this state the material does not recover completely after removal of the stress, that is to say, the deformation is permanent, but there is no failure. Only when the stress reaches the "ultimate strength" does failure, i. e., breakage, occur.

3.75 Ideally, a structure which is to suffer little damage from blast should have as much elasticity as possible. Unfortunately, structural materials are generally not able to absorb much energy in the elastic range, although many common materials can take up large amounts of energy in the plastic range before they fail. The problem in blast-resistant design, therefore, is to decide how much permanent (plastic) deformation can be accepted before a particular structure is rendered useless. This will, of course, vary with the nature and purpose of the structure. Although deformation to the point of collapse is definitely undesirable, some lesser deformation may not seriously interfere with the continued use of the structure.

3.76 It is evident that ductility is a desirable property of structural materials required to resist blast. Structural steel and steel reinforcement have this property to a considerable extent. They are able to absorb large amounts of energy, e. g., from a blast wave, without failure and thus reduce the chances of collapse of the structure in which they are used. Steel has the further advantage of a higher yield point (or elastic limit) under dynamic than under static loading.

3.77 Although concrete alone is not ductile, when steel and concrete are used together, as in reinforced-concrete structures, the ductile behavior of the steel will usually predominate. The structure will then have considerable ductility and, consequently, resistance to blast. Without reinforcement, masonry walls are completely lacking in ductility and readily suffer brittle failure, as stated above.

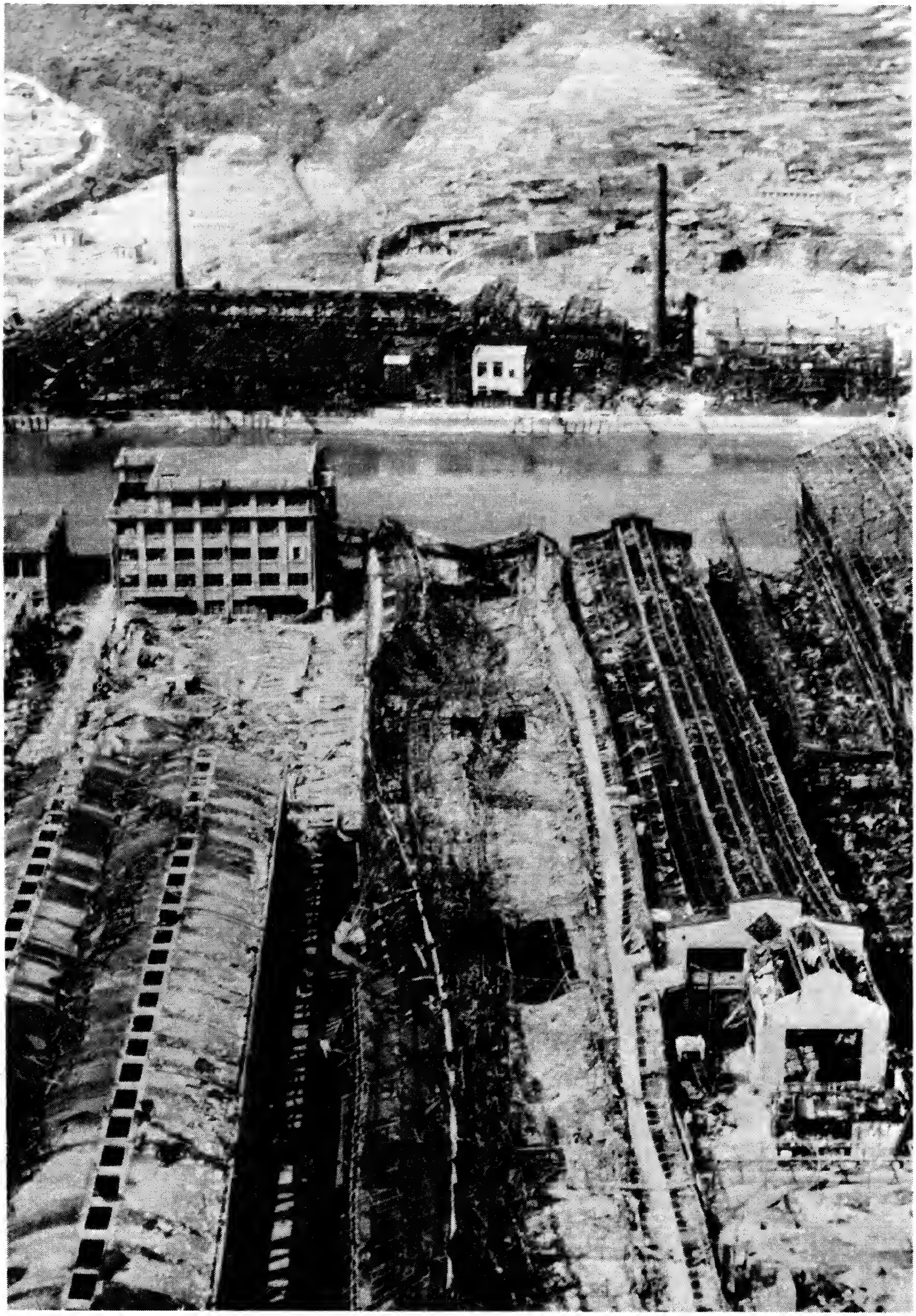


Figure 4.87. At left and back of center is a multistory, steel-frame building (0.85 mile from ground zero at Nagasaki).

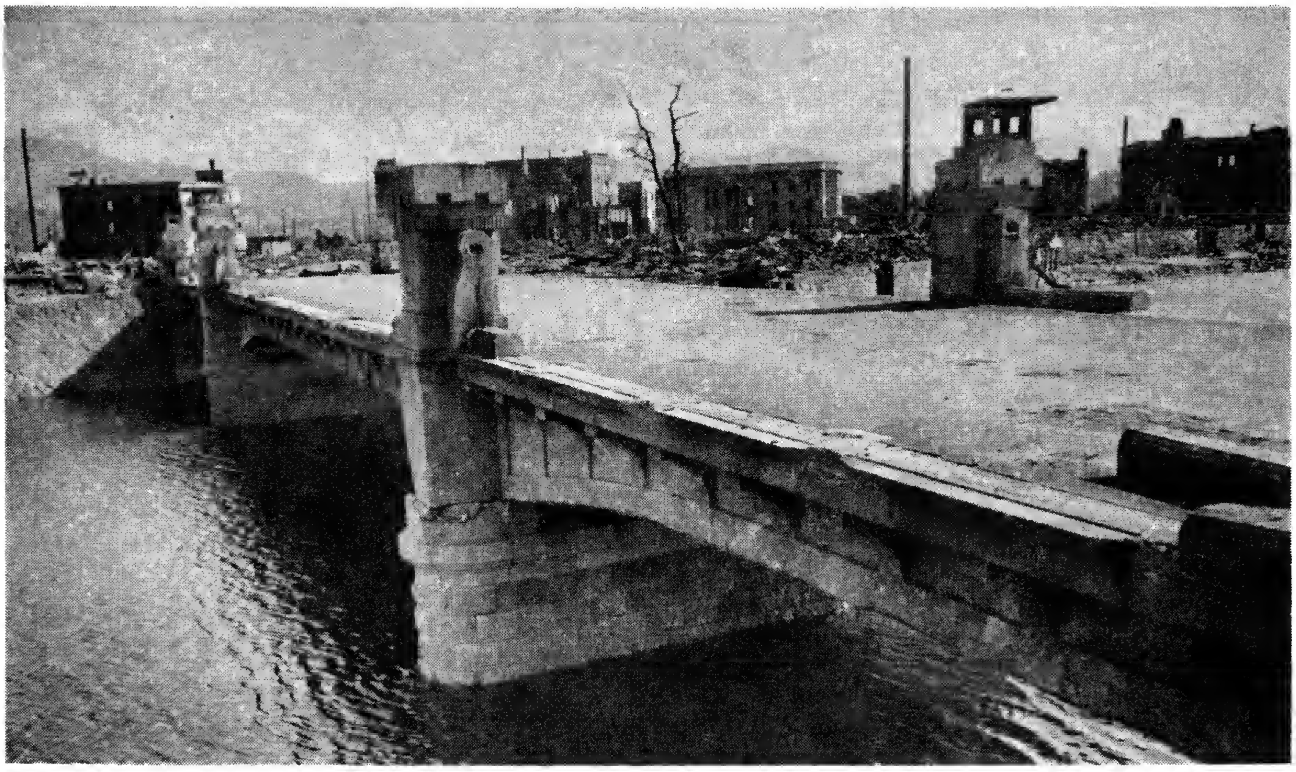


Figure 4.90a. Bridge with deck of reinforced concrete on steel-plate girders: outer girder had concrete facing (270 feet from ground zero at Hiroshima). The railing was blown down but the deck received little damage so that traffic continued.

Figure 4.90b. A steel-plate girder, double-track railway bridge (0.16 mile from ground zero at Nagasaki). The plate girders were moved about 3 feet by the blast; the railroad tracks were bent out of shape and trolley cars were demolished, but the poles were left standing.

(Optimum air bursts extend surface burst blast ranges by up to 50%)

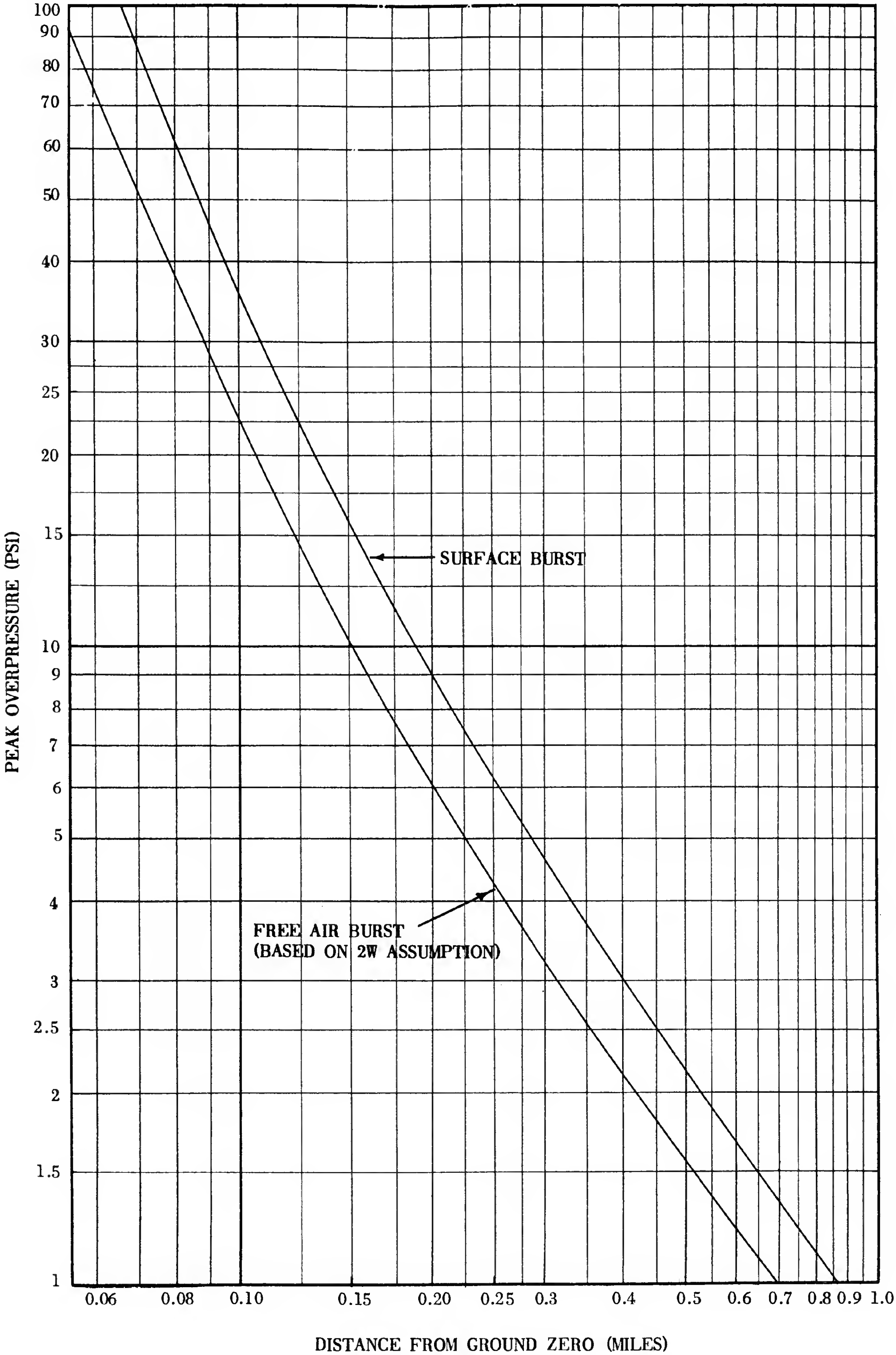


Figure 3.94a. Peak overpressure for a 1-kiloton surface burst and free air burst.

Scaling. For yields other than 1 KT, the range to which a given overpressure extends scales as the cube root of the yield, i. e., $W^{1/3}$

Figure 4.37. Reinforced precast concrete house before a nuclear explosion, Nevada Test Site.

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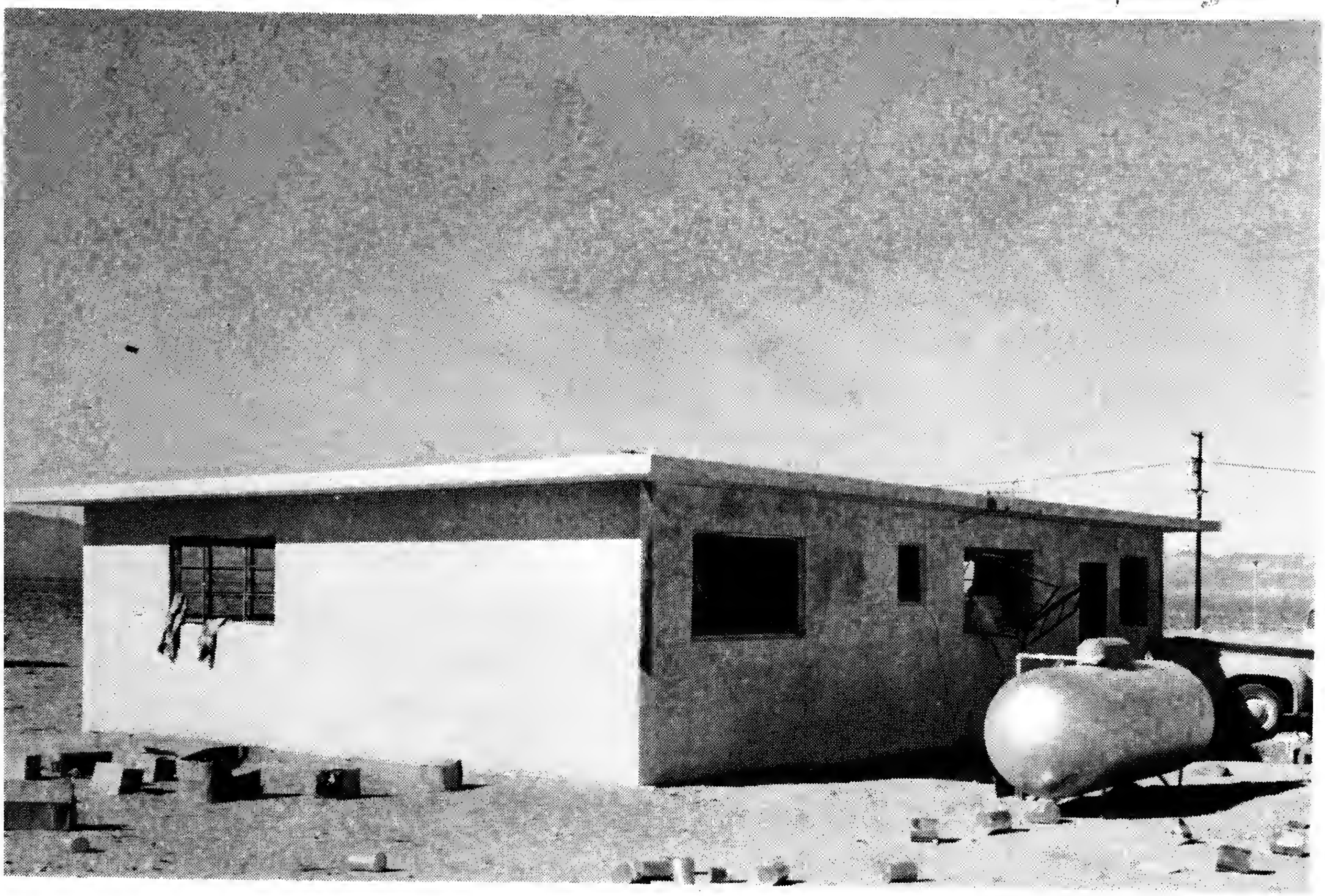

Figure 4.38. Reinforced precast concrete house after the nuclear explosion (5 psi overpressure). The LP-gas tank, sheltered by the house, is essentially undamaged.

Trailer-Coach Mobile Homes

4.45 Sixteen trailer coaches, of various makes, intended for use as mobile homes, were subjected to blast in the 1955 test. Trailer parks and dealer stocks are generally situated at the outskirts of cities, and so the mobile homes to be tested were placed at a considerable distance from ground zero. Nine trailer-coach mobile homes were located where the peak blast overpressure was 1.7 pounds per square inch, and the other seven where the overpressure was about 1 pound per square inch. They were parked at various angles with respect to the direction of travel of the blast wave.

4.46 At the higher overpressure two of the mobile homes were tipped over by the explosion. One of these was originally broadside to the blast, whereas the second, at an angle of about 45°, was of much lighter weight. All the others at both locations remained standing. On the whole, the damage sustained was not of a serious character. There were variations from one trailer-coach to another subjected to the same blast pressure, due to different methods of construction, types of fastening, gage and design of die-formed metal, spacing of studs, and window sizes.

4.47 From the exterior, many of the mobile homes showed some dents in walls or roof, and a certain amount of distortion. There were, however, relatively few ruptures. Most windows were broken, but there was little or no glass in the interior, especially in those coaches having screens fitted on the inside. Where there were no screens or venetian blinds, and particularly where there were large picture windows, glass was found inside.

4.48 The interiors of the mobile homes were usually in a state of disorder due to ruptured panels, broken and upset furniture, and cupboards, cabinets, and wardrobes which had been torn loose and damaged. Stoves, refrigerators, and heaters were not displaced, and the floors were apparently unharmed. The plumbing was, in general, still operable after the explosion. Consequently, by rearranging the displaced furniture, repairing cabinets, improving window coverings, and cleaning up the debris, all trailer-coaches could have been made habitable for emergency use.

Figure 4.29. Unreinforced brick house before a nuclear explosion, Nevada Test Site.

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Figure 4.30. Unreinforced brick house after the nuclear explosion (5 psi overpressure).

⇒ SPACE UNDER STAIRS SURVIVED!

6.8 The usual method of providing earth cover for surface or "cut-and-cover" structures is to build an earth mound over the portion of the structure that is above the normal ground level. The earth mound reduces the blast reflection factor (see Fig. 6.82a) and improves the aerodynamic shape of the structure. This results in a considerable reduction in the applied translational forces. An additional benefit of the earth cover is the stiffening or resistance to motion that the earth provides to flexible structures by the buttressing action of the soil.

6.9 Light-weight, shallow buried underground structures are those constructed deep enough for the top of the earth cover to be flush with the original grade. However, they are not sufficiently deep for the ratio of span to depth of burial to be large enough for any benefit to be derived from soil arching (see § 6.11). For depths of cover up to about 10 feet in most soils, there is little attenuation of the air blast pressure applied to the top surface of a shallow buried underground structure. The results of full scale nuclear tests in Nevada indicate that there is apparently no increase in pressure exerted on the structure due to ground shock reflection at the interface between the earth and the top of the structure.

6.10 The lateral pressures exerted on the vertical faces of a buried structure have been found to be as low as 15 percent of the pressure on the roof in dry, well-compacted, silty soils. For most soils, however, this lateral pressure is likely to be somewhat higher and may approach 100 percent of the roof pressure in porous saturated soil. The pressures on the bottom of a buried structure, in which the bottom slab is a structural unit integral with the walls, may range from 75 to 100 percent of the pressure exerted on the roof.

6.11 Underground structures, buried at such a depth that the ratio of the burial depth to the span approaches (or exceeds) unity, will obtain some benefit from the arching effect of the soil surrounding the structure. Limited experience at the Nevada Test Site has indicated that the arching action of the soil effectively reduces the loading on flexible structures, although the exact extent is at present uncertain.

6.12 The damage that might be suffered by a shallow buried structure will depend on a number of variables, including the structural characteristics, the nature of the soil, the depth of burial, and the downward pressure, i. e., the peak overpressure of the air blast wave. In Table 6.12 are given the limiting values of the peak overpressure required to cause various degrees of damage to two types of earth-covered structures. The range of pressures is intended to allow for differences in structural design, soil conditions, shape of earth mound,

and orientation with respect to the incident blast wave. The damage-distance relationships for these structural types are summarized in Fig. 6.41a.

TABLE 6.12

DAMAGE CRITERIA FOR SHALLOW BURIED OR EARTH COVERED SURFACE STRUCTURES

Type of structure	Damage class	Peak over-pressure (psi)	Nature of damage
Light, corrugated steel arch, surface structure (10-gage corrugated steel with a span of 20 to 25 feet) with 3 feet of earth cover over the crown.	A	35–40	Complete collapse.
	B	30–35	Collapse of portion of arch facing blast.
	C	20–25	Deformation of end walls and arch, possible entrance door damage.
	D	10–15	Possible damage to ventilation system and entrance door.
Light, reinforced-concrete surface or underground shelter with 3 feet minimum earth cover. (Panels 2 to 3 inches thick, with beams spaced on 4-foot centers.)	A	30–35	Collapse.
	B	25–30	Partial collapse.
	C	15–25	Deformation, severe cracking and spalling of panels.
	D	10–15	Cracking of panels, possible entrance door damage.

6.13 An illustration of B-type damage to a 10-gage corrugated steel-arch, earth-covered, surface structure is shown in Fig. 6.13. It will be noted that about half of the arch has collapsed. This failure was attributed primarily to the dynamic pressure acting on the forward slope of the earth mound.

6.14 The peak overpressure for the complete collapse of the corrugated steel-arch structure, with 3 feet of earth cover, is given in Table 6.12 as 35 to 40 pounds per square inch. However, it has been estimated that if this structure had been completely buried, so that no earth mound was required, an overpressure of 40 to 50 pounds per square inch would have been necessary to cause it to collapse. This increase in the required overpressure is due to the fact that the dynamic pressure is minimized under these conditions. It may be mentioned

Figure 6.13. B-type damage to earth-covered 10-gage corrugated steel structure.

that, using standard engineering techniques, it is possible to design underground structures which will withstand blast overpressures in excess of 100 pounds per square inch at the surface (see Chapter XII).

12.15 In general, there are three main aspects in which blast-resistant design differs from the design procedures for static loads. First, mass is important, since, as structural displacement takes place, the various masses undergo large accelerations. Other things being equal, a heavy structure will usually withstand the action of blast better than one that is less massive. Second, many structural materials, including steel, concrete, and even wood, exhibit increased strength when subjected to rapid rates of strain, such as would occur when exposed to a blast wave. For high rates of loading the yield point may be increased 50 percent or more over the value at low rates of loading. Third, if ductile materials are used in blast-resistant design, it is possible and may be desirable for economic reasons to permit strains beyond the elastic limit.

12.16 Some degree of permanent deformation may be acceptable before a structure is rendered useless for its main purpose, and this can be taken into consideration in its design. The steel-mill type of building is a good example of a structure in which large permanent deformation may be accepted. On the other hand, office buildings, apartment houses, etc., containing elevator shafts, partitions, doors, windows and concealed utilities, may have their usefulness impaired by much smaller deformations.

12.17 In designing a particular type of structure to resist blast, it is necessary first to postulate the blast wave characteristics, i. e., the peak overpressure and dynamic pressure, and their variation with time. These factors depend upon the energy yield of the explosion, the expected distance of the structure from the point of burst, and the height of burst. Since none of these variables can possibly be known in advance, the postulates concerning the blast load which the structure is required to withstand inevitably involve considerable uncertainty. The choice of the blast load for design purposes must be based on a balance between the cost and the over-all importance of the particular structure.

12.18 After the loading has been prescribed, a dynamic analysis of the proposed structure must be undertaken to determine the stiffness and ultimate strength necessary to prevent collapse or to limit the plastic deformation to some specified amount. This limit will be determined by the functional requirements of the activities or operations for which the structure is to be used. The critical deformation may be restricted to that which will prevent the structure from collapsing, so that personnel can be protected and the contents of the building salvaged; or it may be required that the building shall still be capable of use for conventional loads after the blast. The next step in the

design is then to prepare specifications of the structural members and connections to supply the required strength and stiffness.

12.19 The detailed methods and procedures of dynamic design are probably necessary in order to predict accurately the behavior of a structure exposed to loading from a blast wave. However, this requires familiarity with methods not customarily used in conventional engineering design.

Structural Materials

12.20 In choosing structural materials it should be borne in mind that the energy absorbed by a structure undergoing plastic deformation can make an important contribution to resistance to dynamic loading. Brittle materials, e. g., glass, cast iron, and unreinforced masonry, cannot tolerate strains beyond the elastic limit without suffering failure by rupture. Upon failure, these materials can produce dangerous missiles and so should be avoided for this reason also (see § 12.35). On the other hand, ductile materials, e. g., structural steel, reinforced concrete, and reinforced masonry, can undergo considerable plastic deformation without collapse and, in many cases, without appreciable loss of strength.

12.21 Reinforced concrete offers many advantages as a structural material, since it has characteristics desirable in blast-resistant construction. The large mass and sluggish response of the relatively heavy members, and the continuity which is possible, contribute to the ability to withstand lateral forces. Concrete can be used for shear walls which provide resistance to motion and add little to the cost of the building.[2] The bulkiness of the members may be somewhat objectionable, although thick concrete walls can help in attenuating nuclear radiation.

Types of Blast-Resistant Multistory Structures

12.22 The type and arrangement of a structure designed to have appreciable resistance to blast will depend, to some extent, upon the intended use of the structure. In general, the ability to withstand the lateral forces due to blast will increase with the strength, rigidity, ductility, and mass of the members enclosing and supporting the

[2] Shear walls are walls (or partitions) designed for horizontal loads applied in the plane of the wall, as distinct from loads perpendicular to the wall. Shear walls may, of course, be designed to take such lateral loads as well.

structure. There are, however, certain structural forms which are inherently more suited to resist blast loading.

12.23 If the presence of solid or almost solid exterior walls and cross walls can be tolerated in the functional layout of the building, a satisfactory and economical design for a multistory structure appears to be a reinforced-concrete, shear-wall building. Shear-wall structures derive their principal strength from structural walls capable of resisting large lateral loads. Such walls are usually so stiff compared to beams and columns, which may be used in conjunction with shear walls, that essentially all the translational load is carried by these walls.

12.24 Where interior walls are required as fire barriers, stairwell enclosures, or partitions, these may be designed, with advantage, as shear walls. The same walls can then be used to carry vertical loads, thus replacing the framing ordinarily employed for this purpose. It is desirable, however, in the construction of bearing walls, supporting floor and roof systems, to avoid the use of unreinforced brick, stone, or block, since they are vulnerable to relatively low pressures acting transversely to the walls.

12.25 When the operations to be performed in the building are such as to rule out solid (or nearly solid) exterior walls, then partially solid shear walls at the ends of the building, in addition to fire walls and fixed partitions of shear-wall design, are desirable. This will permit the use of light columns designed to carry the vertical loads for the rest of the framing. Even if shear walls are limited to stairwells, elevator shafts, and to walls around the plumbing and duct passages, an important degree of blast resistance can be achieved at minimum cost.

12.26 The presence of window openings and light curtain walls may have some advantages. Windows and light partitions will fail rapidly, when exposed to blast, without offering substantial resistance. As a result there will be a decrease in the lateral impulsive load, due to the reduction in the effective resisting area, before appreciable deformation occurs. While these openings might be helpful in minimizing damage to the frame and decreasing the danger of overturning, they may be expected to increase both the hazard to personnel in the building and the destruction of its contents. LIE DOWN/DUCK !!

12.27 In the construction of a reinforced-concrete building it is essential that there should be good continuity at all joints subject to appreciable bending or shearing stresses in order to insure monolithic behavior. All intersecting walls and floors should be securely doweled together with reinforcement, and construction joints between previ-

ously poured and fresh concrete should be prepared to provide maximum bonding between the old and the new.

12.28 A reinforced-concrete structure, with shear walls and partitions having good continuity, will act as a single cell. The walls of the structure will then transmit floor and roof reactions to the foundations. Heavy beams or supporting columns can thus be eliminated and good resistance to blast forces retained.

12.29 For steel-frame structures with diagonal bracing there is a possibility of complete failure by local rupture of the bracing material. Sufficient load-carrying capacity must be provided in the bracing to prevent this from occurring. In order to insure full utilization of the members of the frame, the strength of the end connections of a diagonal brace should always be greater than that of the member itself.

12.30 In tier buildings with steel skeleton frames, the strength of the end connections should be sufficient to develop the ultimate strength of the members of the frame. If the floor slabs are keyed to the structural steel frame by means of bond or shear developers, so as to provide composite behavior, both the steel and the concrete contribute strength to the framework. Wall panels should be attached to the building frames in such a manner that the connections will withstand rebound loads as well as the positive and negative loads due to the blast wave.

Reducing Blast Hazard in Existing Buildings

12.31 Aside from the question of the design of new construction considered above, there is the possibility of making changes in existing buildings so as to reduce the damage to their contents and injury to personnel resulting from blast action. This is a more difficult problem than that of incorporating appropriate measures in new design. The most serious danger to persons and equipment in a building is from total, or even partial, collapse. It is necessary, therefore, to analyze the structure in order to discover the weak points, and then to determine the best methods for strengthening them.

12.32 As a general rule, it will not be possible to strengthen the frame of a reinforced-concrete building, but increased resistance to collapse can be achieved by replacing interior walls, wherever possible, by shear walls. The addition of bracing can be effective in increasing the strength of a steel-frame building.

12.33 From an over-all point of view, an important consideration is the reduction in hazard to persons in a building strong enough not

to collapse even though it might be damaged to some extent. Well-attached, reinforced-concrete or reinforced-masonry walls, on a frame of either structural steel or reinforced concrete, will provide a high degree of protection to persons inside the building. This type of construction will also contribute a minimum number of missiles. A poorly attached wall of unreinforced masonry, on the other hand, would provide almost no protection inside the building and would supply missiles both inside and outside.

12.34 Existing frames of steel or reinforced concrete may be strengthened by filling the areas between the columns and beams with shear walls. The effectiveness of such walls will depend upon their strength and also upon the strength of the connections between shear walls and floors, since in order for such walls to be effective they must carry the lateral forces to the foundation. Inclusion of shear walls of this type in a frame structure creates a new unit of greatly increased strength.

12.35 In all structures, no matter how blast resistant they may be, it is important to minimize the danger from flying glass, displaced equipment, falling fixtures, and false ceilings. The great hazard to personnel due to glass should be considered in design, and glass areas should be provided only to the extent essential for the use of the building. BUT DUCK & COVER PROVIDES PROTECTION!

12.36 Consideration should be given to the hazard in existing structures from fixtures and heavier ornamental plaster or other interior treatment that might be detached by the blast or by the wracking action of the building. The best procedures would be to remove any such hazardous items if possible. If this is not fully practicable, such partial safeguards should be provided as may appear feasible. Overhanging cornices and finials on the outside of a building will be a danger to persons in the vicinity, and their removal should be considered. Although the flying missile hazard is not peculiar to nuclear weapons, it is, nevertheless, one which is greatly magnified by the high pressures and long duration of the blast wave.

12.37 Blast walls of the type employed to localize destruction from ordinary high-explosive bombs will perhaps be helpful, to some extent, in reducing injuries from flying missiles and in protecting essential equipment (Figs. 12.37a and b). Particular care should be taken to make such walls resistant to overturning. Both reinforced-concrete walls and earth-filled wooden walls (Fig. 12.37c) were used in Japan for protection against blast. The former were more effective, but the latter, even though badly damaged by the nuclear bomb blast, did prevent serious harm to equipment.

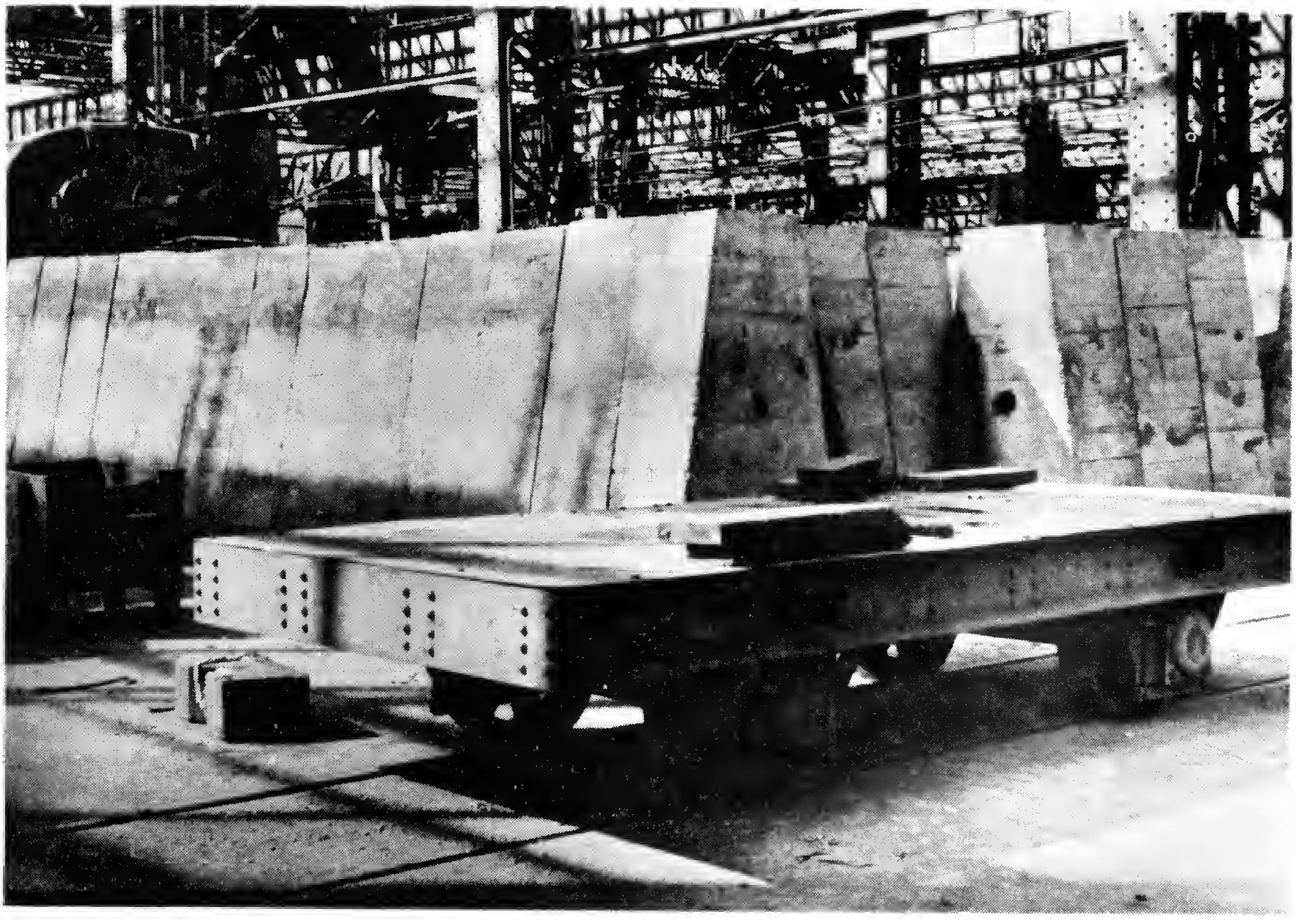

Figure 12.37a. Precast, reinforced-concrete blast walls (0.85 mile from ground zero at Nagasaki).

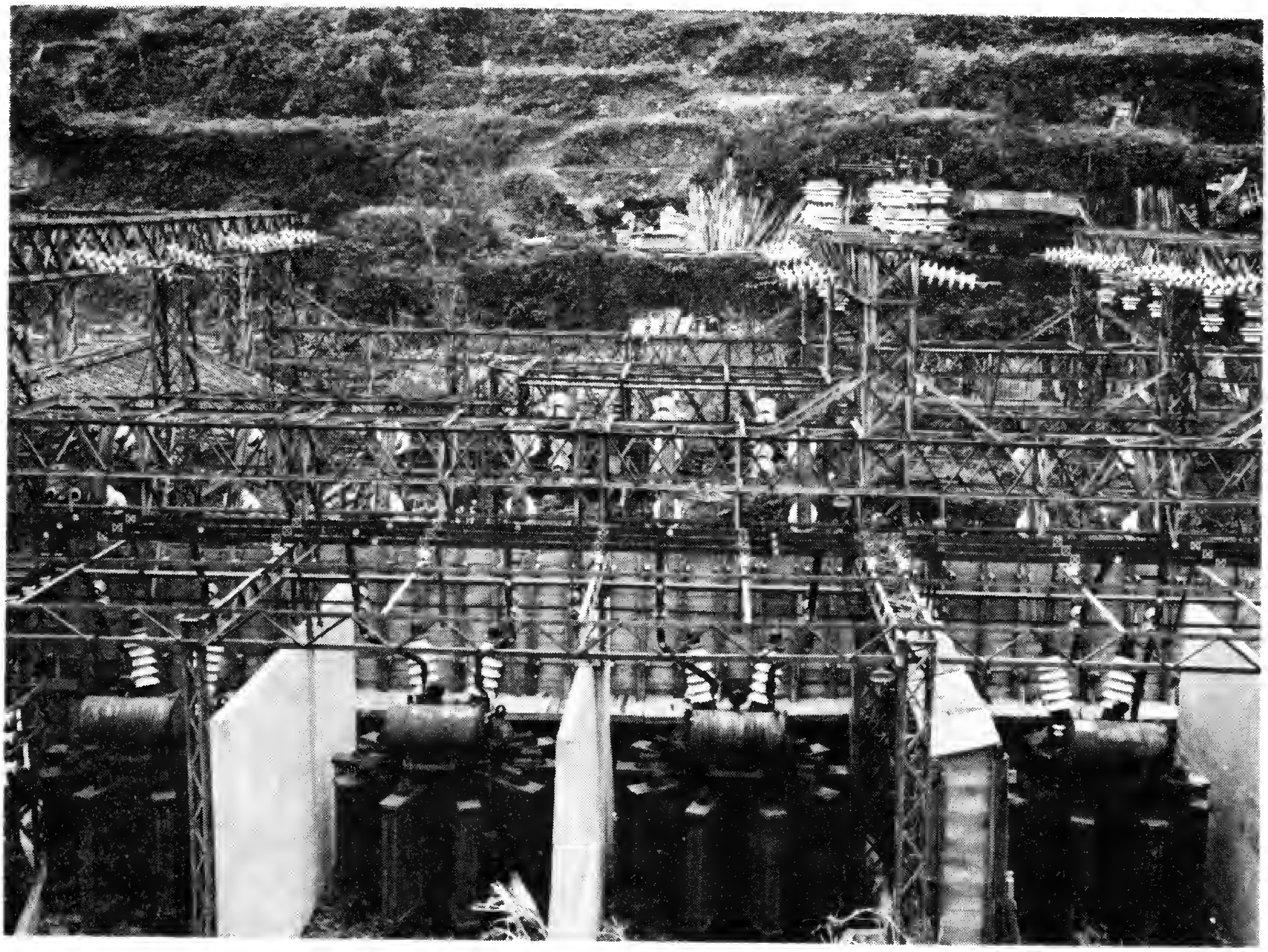

Figure 12.37b. Reinforced-concrete blast walls protecting transformers (1 mile from ground zero at Nagasaki).

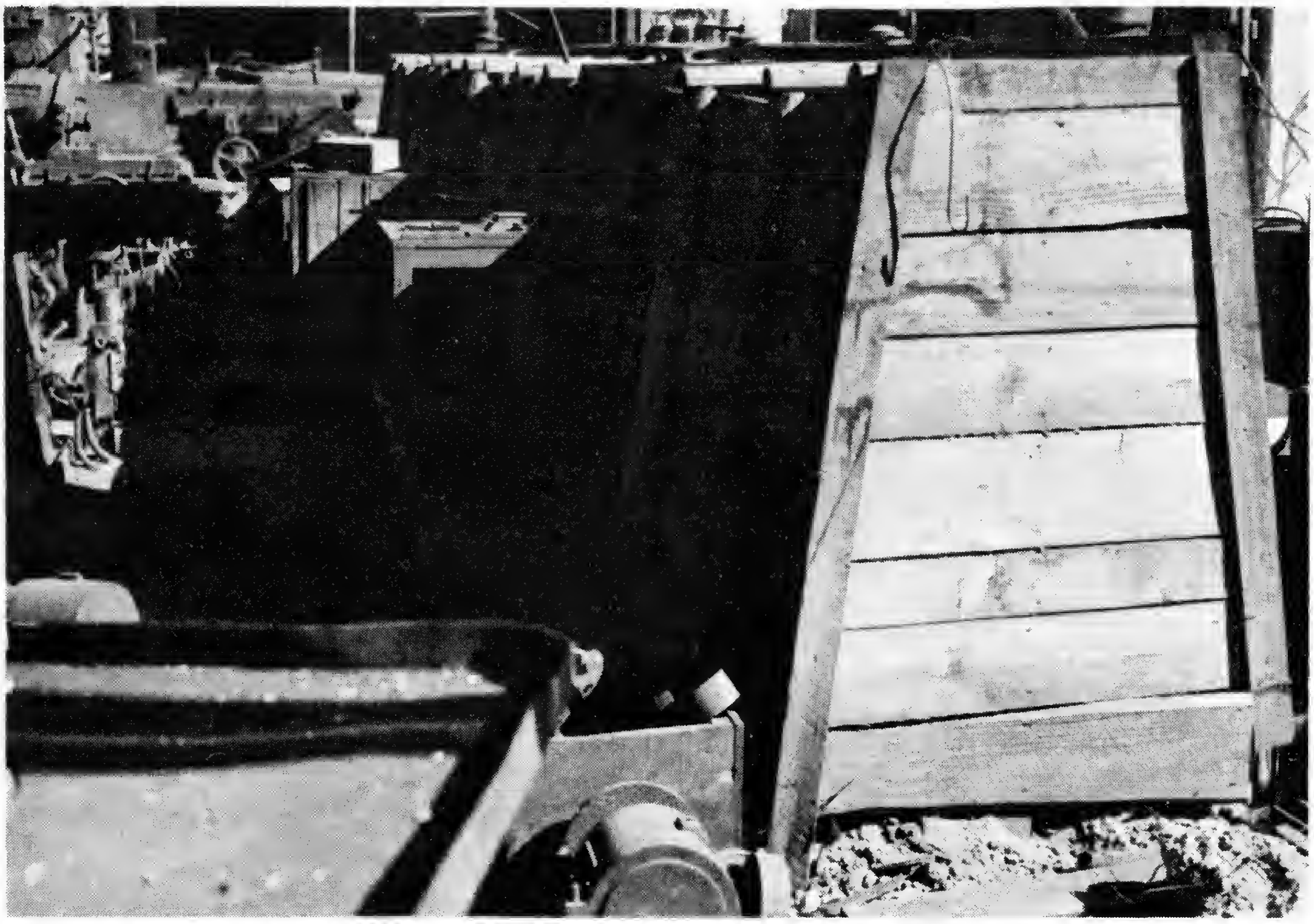

Figure 12.37c. Earth-filled, wooden blast walls protecting machinery (0.85 mile from ground zero at Nagasaki).

Protection by Trenches and Earth Revetments

12.38 Although they are not strictly structures, in the sense used above, attention should be called to the significant protection that can be afforded by trenches and earth revetments, especially to drag-sensitive targets. A shallow pit provides little shielding, but pits or trenches that are deeper than the target have been found to be very effective in reducing the magnitude of the drag forces impinging on any part of the target. In these circumstances, the lateral loading is greatly reduced and the damage caused is restricted mainly to that due to the crushing action of the blast wave.

12.39 The only types of shielding against drag forces which have been found to be satisfactory so far are those provided by fairly extensive earth mounds (or revetments) and deep trenches, since these are themselves relatively invulnerable to blast. Such protective trenches are not recommended for use in cities, however, because of the damage that would result from debris falling into them. Although sandbag mounds have proved satisfactory for protection against conventional high explosives and projectiles, they are inadequate against nuclear blast because they may become damaging missiles.

Figure 12.40a. Earth-moving equipment subjected to nuclear blast in open terrain (30 psi overpressure).

Figure 12.40b. Earth-moving equipment subjected to nuclear blast in open terrain (30 psi overpressure).

Figure 12.40c. Earth-moving equipment protected in deep trench at right angles to blast wave motion (30 psi overpressure).

12.40 The destruction caused by a nuclear explosion to two pieces of earth-moving equipment, which are largely drag-sensitive, is shown in Figs. 12.40a and b. Two similar pieces of equipment located in a deep trench, at the same distance from the explosion, are seen in Fig. 12.40c to have been essentially unharmed. It is important to mention that the main direction of the trench was at right angles to the motion of the blast wave. If the wave had been traveling in the same direction as the trench, the equipment would probably have been severely damaged. Consequently, in order to provide protection from drag forces, the orientation of the trench or earth revetment, with respect to the expected direction of the explosion, is of great importance.

Fire Protection

12.41 It was noted in Chapter VII that fires following a nuclear explosion may be started by thermal radiation and by secondary effects, such as overturning stoves and furnaces, rupture of gas pipes, and electrical short circuits. Fire-resistive construction and avoidance of fabrics and other light materials of inflammable character are essential in reducing fire damage. As shown by the tests described in § 7.82, a well-maintained house, with a yard free from inflammable rubbish, was less easily ignited by thermal radiation than a house that has not had adequate care.

12.42 The methods of fire-resistive design and of city planning are well known and the subject need not be treated here. A special requirement is the reduction of the chances of ignition due to thermal radiation by the avoidance of trash piles and other finely divided fuel as well as combustible, especially dark colored, materials that might be exposed at windows or other openings. It has been recommended, in this connection, that all such openings be shielded against thermal radiation from all directions. The simple device of whitewashing windows will greatly reduce the transmission of thermal radiation and so decrease the probability of fires starting in the interior of the building. Other practical possibilities are the use of metal venetian blinds, reflective coatings on the window glass, and nonflammable interior pull curtains.

12.43 To judge from the experience in Japan, where the distortion by heat of exposed structural frames was considerable, it would appear desirable that steel columns and other steel members be protected from fire, especially where the contents of the building are flammable or where the building is located adjacent to flammable structures. Further, narrow firebreaks in Japan were found to be of little value. It is vital, therefore, that such firebreaks as may be provided in city planning or by demolition must be adequate for a major conflagration. A minimum width of 100 feet has been suggested.

12.44 One of the most important lessons learned from the nuclear bomb attacks on Japan is the necessity for the provision of an adequate water supply for the control of fires. In Nagasaki, the water pressure was 30 pounds per square inch at the time of the explosion, but chiefly because of numerous breaks in house service lines it soon dropped to 10 pounds per square inch. On the day following the explosion the water pressure was almost zero. This drop in the pressure contributed greatly to the extensive damage caused by fire. The experience in Hiroshima was quite similar.

SHELTERS FOR PERSONNEL

Introduction

12.45 Ideally, a shelter for personnel might be required to provide protection against air blast, ground shock, thermal radiation, initial nuclear radiation (neutrons and gamma rays), and residual nuclear radiation from fallout (external and internal sources). Such an ideal shelter is, however, virtually impossible to attain, in view of the uncertainties mentioned in § 12.2.

Underground Personnel Shelter

12.53 Where essential industrial, civic, or military activities must be maintained before, during, and after a nuclear attack, it might be desirable to have a group shelter which could be occupied continuously, although not necessarily by the same individuals. A shelter of this kind would be of the closed type and would have to be provided with a suitable ventilating system. As a result of various tests, it has been found that in "open" shelters, i. e., in shelters which are open to the entry of the blast, the peak overpressure of the blast wave is not very different from that outside. Some reduction can be achieved by suitable design of the entrance and by the use of baffles, but the general impression is that, in strategic locations, where high overpressures may be expected, open group shelters would not be adequate.

12.54 The general features of a closed, underground personnel shelter, that can accommodate some 30 individuals at a time, but can be extended to hold more, are shown in Fig. 12.54. The design is based on experience gained at various nuclear tests in which shelters of this type have withstood peak overpressures of about 100 pounds per square inch. It was also found, as expected, to produce considerable attenuation of both gamma rays and neutrons.[3]

12.55 The main shelter chamber has reinforced-concrete walls 15 inches thick; the floor slab has a thickness of 18 inches and that of the roof is 21 inches. The chamber is covered with packed earth to a depth of at least 5 feet. The entrance is by concrete steps, in two sections at right angles. Instead of extending in the direction shown in the figure, the entranceway may be turned through 180°, so as to make the whole lay-out more compact. The stairway at the ground level is closed by means of an 8-inch thick horizontal door made of structural steel and reinforced concrete. The door has four wheels and is track mounted. It is so designed that as it rolls closed it seats itself on steel bed plates on each side of the stairwell, so that the blast load is removed from the wheels and axles. A heavy jack is mounted on the underside of the ceiling of the stairwell, so that the door can be forced open in case there is an accumulation of debris in the well behind the door.

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[3] The shelter described here was conceived and planned by the Federal Civil Defense Administration, with the assistance of the Army Ballistics Research Laboratory, the Army Chemical Center, and the Armed Forces Special Weapons Project. The structural design was by Ammann and Whitney, Consulting Engineers, under contract to the Federal Civil Defense Administration.

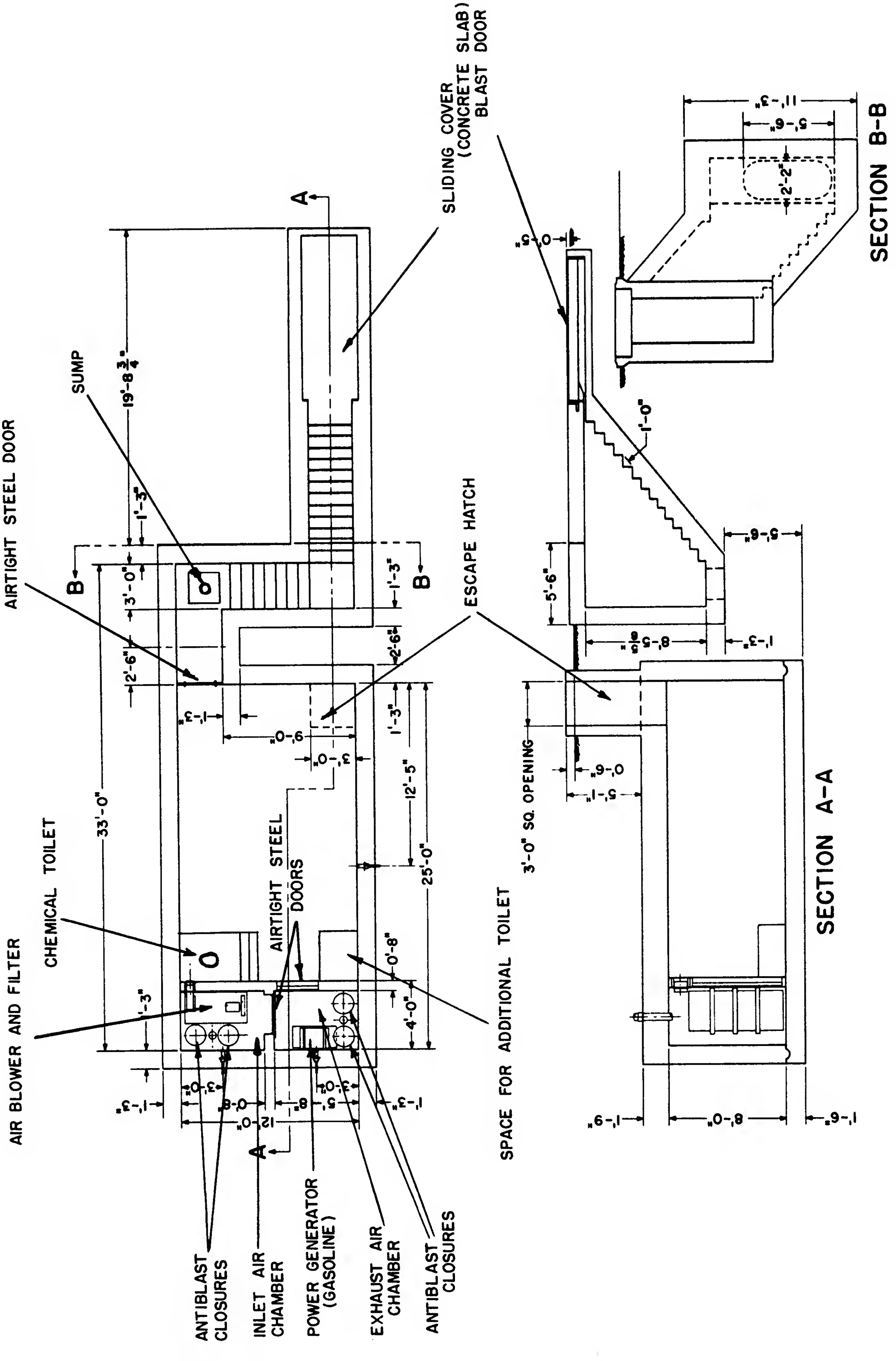


Figure 12.54. Sectional plan and section of underground personnel shelter.

12.56 Entrance to and exit from the shelter chamber is through a doorway fitted with a ½-inch steel, air tight (Navy bulkhead type) door. For emergency exit there is a 3 x 3-feet vertical escape hatch with a steel trap door. Normally the hatch is filled with washed and dried sand, but this can be run out and personnel can escape by climbing a vertical ladder in the wall.

12.57 The ventilation system for the shelter is contained in two compartments shown at the extreme left in Fig. 12.54. Air from outside enters the inlet chamber, passes through a filter, to remove particulate matter, e. g., fallout, as well as biological and chemical warfare agents, and is then blown into the shelter through ducts near the ceiling. The return air is expelled through the exhaust chamber. Both inlet and exhaust systems are fitted with special "anti-blast closures." These are so constructed that a sudden increase in the exterior pressure, due to the passage of a blast wave, will cause them to close almost instantaneously. Relief of the pressure by the negative phase of the blast wave will then open them again. The closures have been found to operate satisfactorily at peak overpressures up to at least 100 pounds per square inch.

12.58 The exhaust chamber also contains a gasoline-driven, electric generator for emergency use in the event of failure of the main power supply. An underground tank holds enough fuel for 10 days. At the other end of the shelter is a buried water tank to provide water for drinking purposes.

Emergency Shelters

12.59 From experience gained in both nuclear and conventional explosions, there is little doubt that it is, as a general rule, more hazardous in the open than inside a structure. In an emergency, therefore, the best available shelter should be taken. Many subways would provide reasonably good emergency shelter, but they are to be found in a limited number of cities. As an alternative, that is more readily available, the basement of a building should be chosen. In this connection, a fire-resistive, reinforced-concrete or steel-frame structure is to be preferred, since there is less likelihood of a large debris load on the floor over the basement. Even basements of good buildings are not, however, an adequate substitute for a well-designed shelter, since the design live loads of floors over basements are usually small in comparison with the blast overpressure to which these floors may be subjected.

12.60 In the event of a surprise attack, when there is no opportunity to take shelter, immediate action could mean the difference between life and death. The first indication of an unexpected nuclear explosion would be a sudden increase of the general illumination. It would then be imperative to avoid the instinctive tendency to look at the source of light, but rather to do everything possible to cover all exposed parts of the body. A person inside a building should immediately fall prone and crawl behind or beneath a table or desk. This will provide a partial shield against splintered glass and other flying missiles. No attempt should be made to get up until the blast wave has passed, as indicated possibly by the breaking of glass, cracking of plaster, and other signs of destruction. The sound of the explosion also signifies the arrival of the blast wave.

12.61 A person caught in the open by the sudden brightness due to a nuclear explosion, should drop to the ground while curling up to shade the bare arms, hands, neck, and face with the clothed body. Although this action may have little effect against gamma rays and neutrons, it might possibly help in reducing flash burns due to thermal radiation. The degree of protection provided will vary with the energy yield of the explosion. As stated in § 7.53, it is only with high-yield weapons that evasive action against thermal radiation is likely to be feasible. Nevertheless, there is nothing to be lost, and perhaps much to be gained, by taking such action. The curled-up position should be held until the blast wave has passed.

12.62 If shelter of some kind, no matter how minor, e. g., in a doorway, behind a tree, or in a ditch, or trench can be reached within a second, it might be possible to avoid a significant part of the initial nuclear radiation, as well as the thermal radiation. But shielding from nuclear radiation requires a considerable thickness of material and this may not be available in the open. By dropping to the ground, some advantage may be secured from the shielding provided by the terrain and surrounding objects. However, since the nuclear radiation continues to reach the earth from the atomic cloud as it rises, the protection will be only partial. Further, as a result of scattering, the radiations will come from all directions.

TABLE 6.29

GROUND SHOCK DAMAGE CRITERIA FOR MODERATELY DEEP UNDERGROUND STRUCTURES

Type of structure	Damage class	Distance from surface zero	Nature of damage
Relatively small, heavy, blast-resistant design (shelters).	A & B	1¼ crater radii.	Collapse or severe displacement.
	C	1¼ to 2 crater radii.	Shock damage to interior equipment.
	D	2 to 2½ crater radii.	Severance of brittle connections, slight cracking at structural discontinuities.
Relatively long, flexible (pipelines).	A	1½ crater radii.	Deformation and rupture.
	B	1½ to 2 crater radii.	Slight deformation with some rupture.
	C	2 to 3 crater radii.	Failure of connections.

6.30 A heavy, reinforced-concrete underground shelter is an example of the first type of structure referred to in Table 6.29. This may be expected to survive just beyond the crater region.

CRATER DIMENSIONS

5.7 It has been estimated that for a 1-kiloton nuclear contact surface burst, the diameter of the crater, i. e., of the hole, will be about 125 feet in dry soil, the lip will extend a further 60 feet or so all around. The depth of the crater is expected to be about 25 feet. In hard rock, consisting of granite and sandstone, the dimensions will be somewhat less. The diameter will be appreciably greater in soil saturated with water, and so also will be the initial depth, to which the structural damage is related. The final depth, however, will be less due to "hydraulic fill", i. e., the slumping back of wet material and the seepage of water carrying loose soil.

5.8 The diameter (or radius) of the crater increases roughly in proportion to the cube root of the energy of the explosion. Hence, for an explosion of W kilotons yield, the diameter will be $W^{1/3}$ times the value quoted above for a 1-kiloton burst. The depth scales approximately according to the fourth root of the energy, for most soils, which means that it increases by a factor of $W^{1/4}$. For example, for a 100-kiloton contact surface burst in dry soil, the diameter of the crater may be expected to be $125 \times (100)^{1/3} = 580$ feet, and the depth $25 \times (100)^{1/4} = 80$ feet.

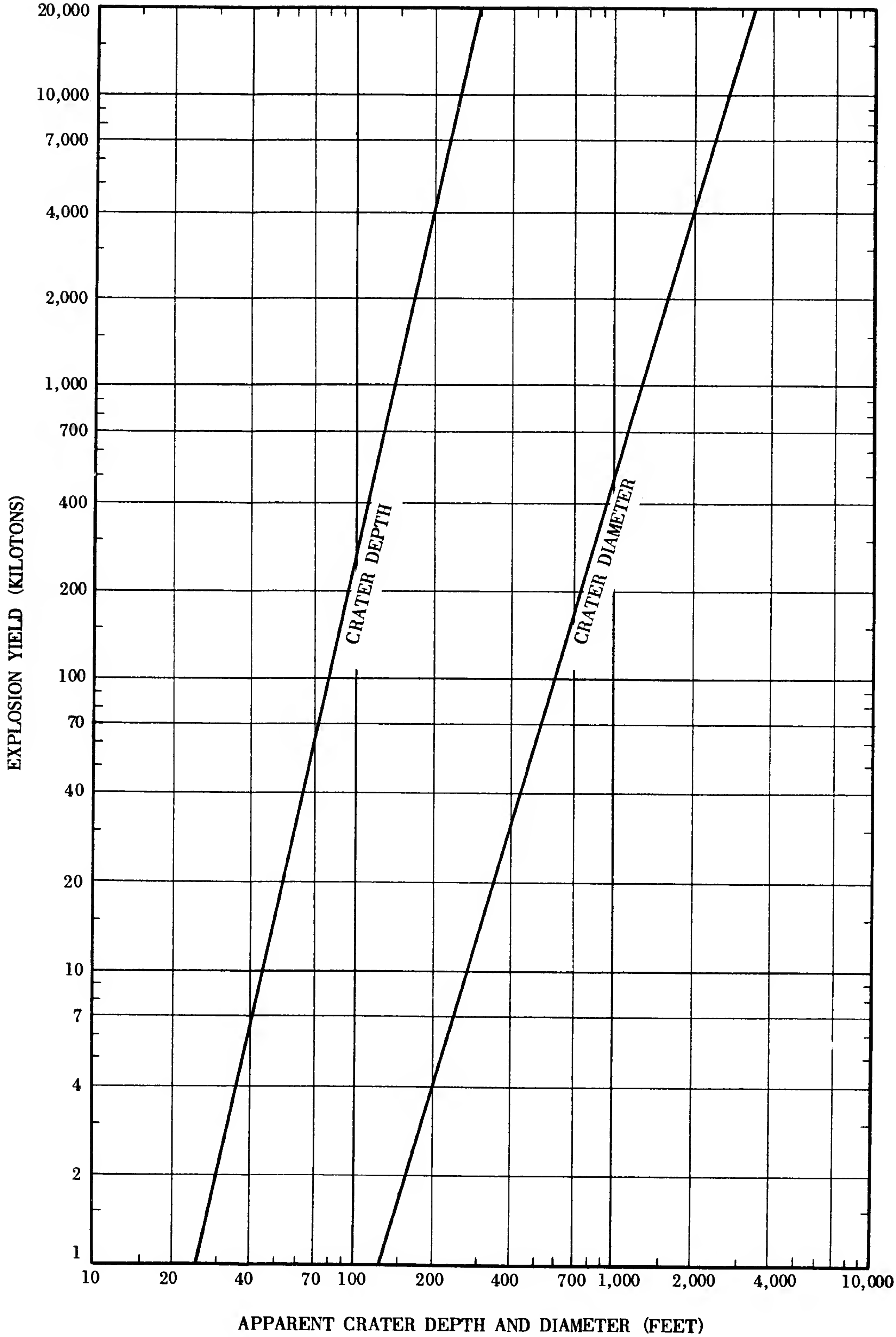


Figure 5.46. Apparent crater depth and diameter for a contact surface burst in dry soil.

IGNORES conservation of energy for gravitation (work E to lift mass M up a height H: E = MgH) and reduced case shock at high x-ray yields

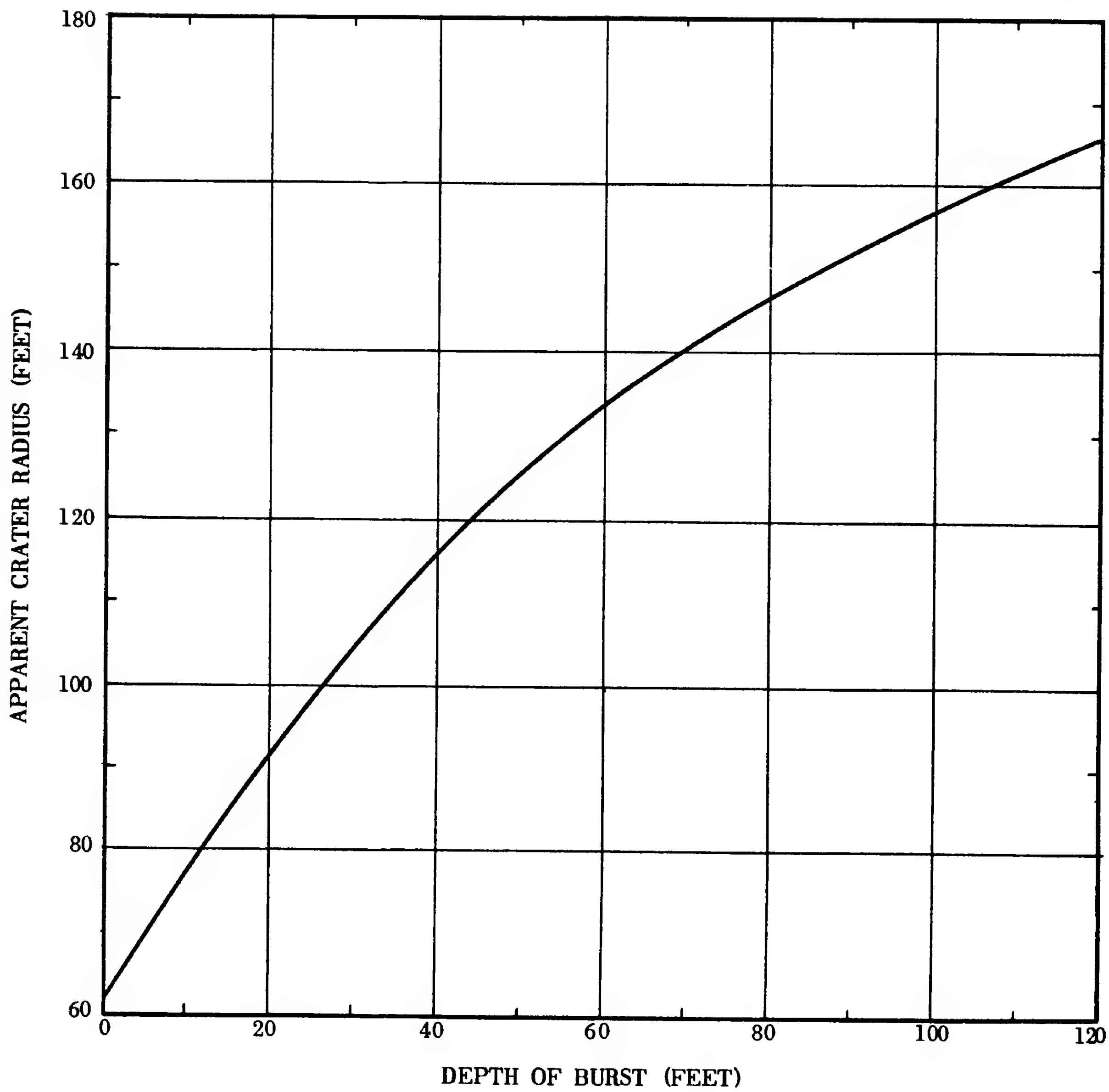


Figure 5.47. Relation of apparent crater radius to depth of burst for 1-kiloton explosion in dry soil.

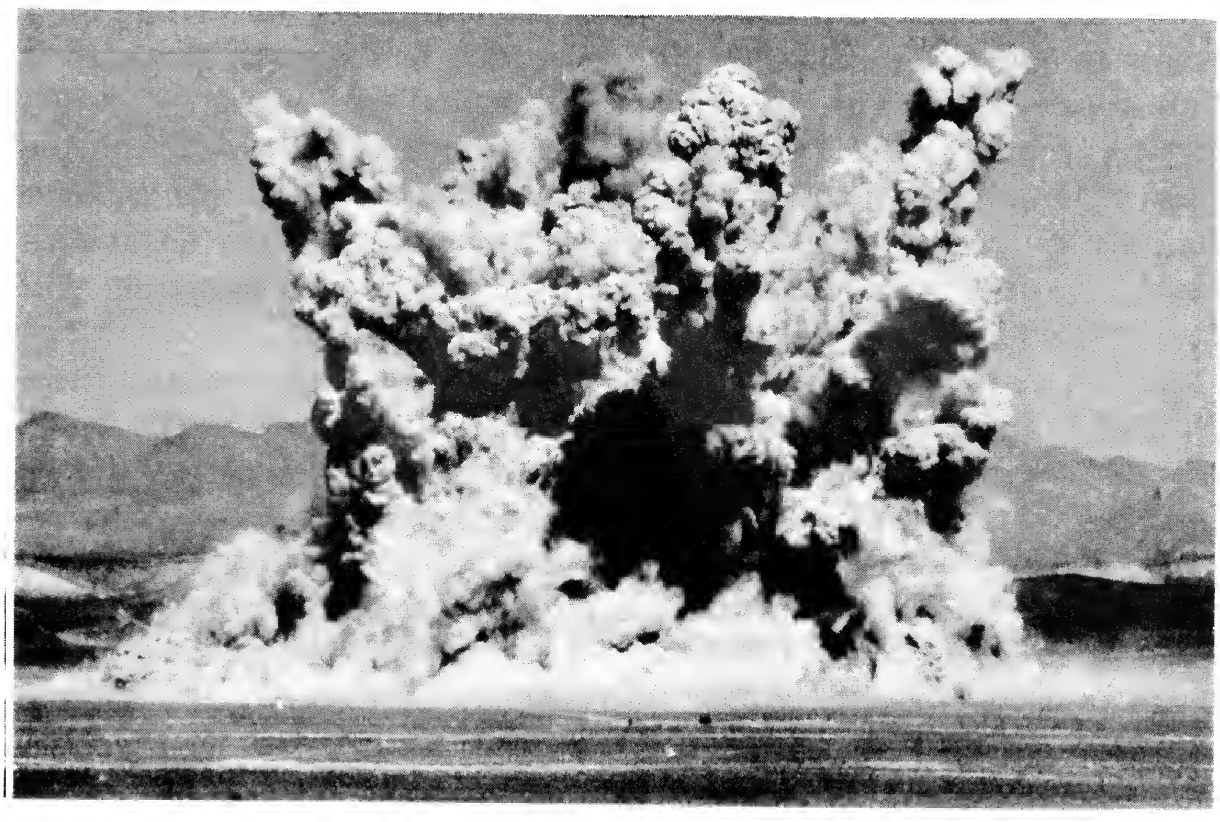


Figure 2.71. Base surge formation in underground burst.

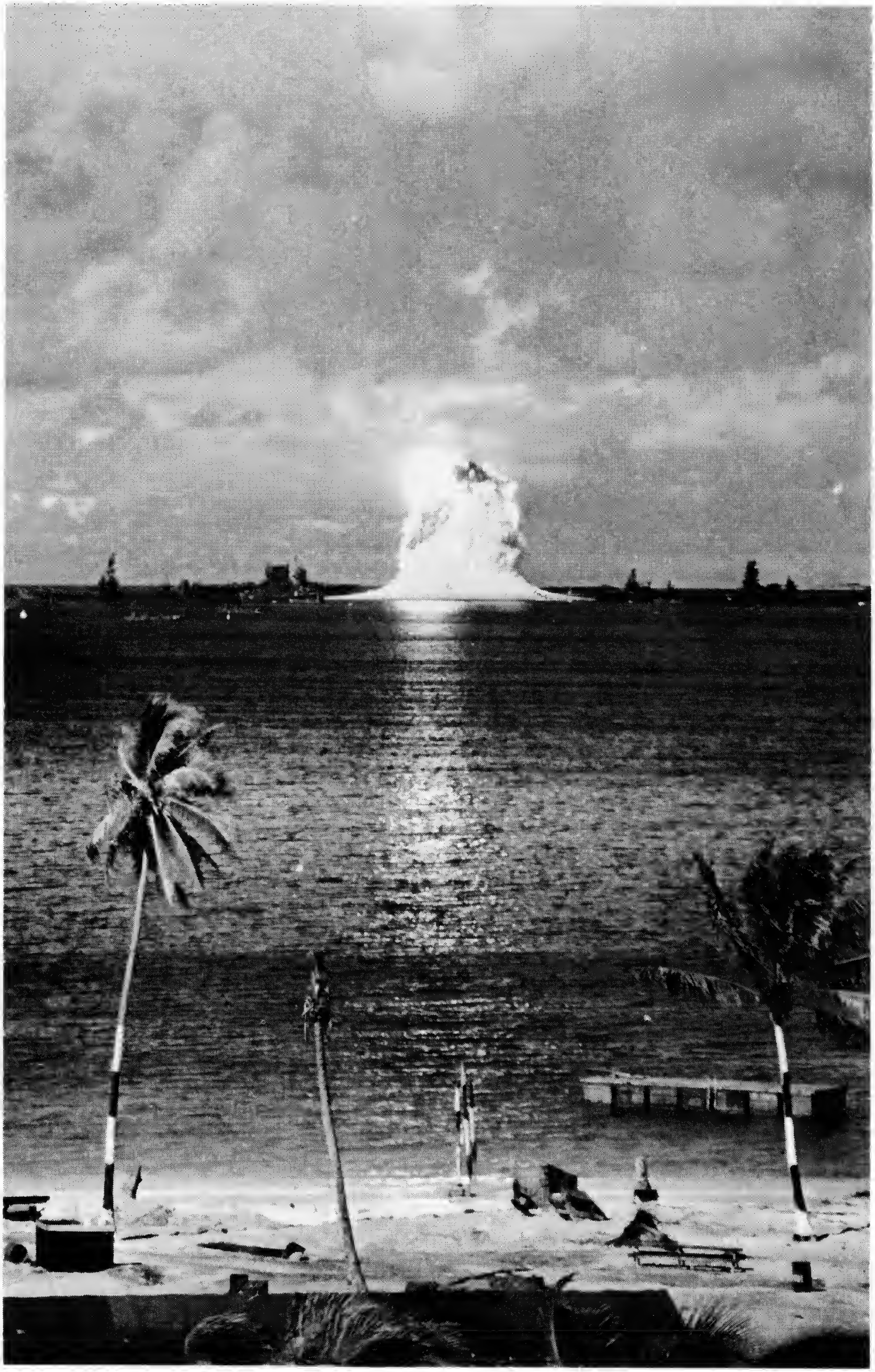


Figure 2.52. The "spray dome" formed over the point of burst in an underwater explosion.

Baker. 4 ms; 2500 ft/sec rise rate.

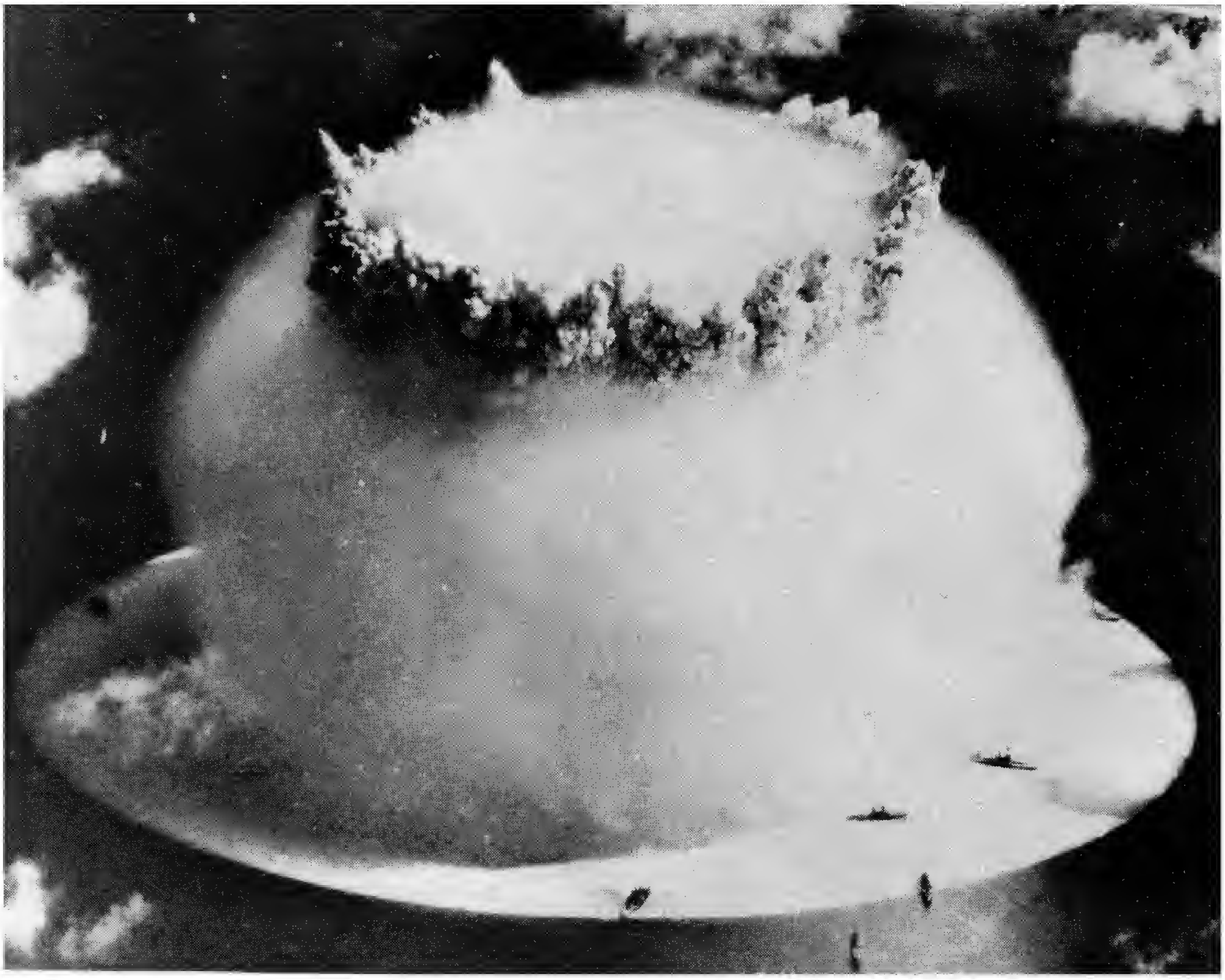


Figure 2.53a. The condensation cloud formed after a shallow underwater explosion. (The "slick," due to the shock wave, can be seen on the water surface.)

Figure 2.53b. Formation of the hollow column in an underwater explosion, the top is surrounded by a late stage of the condensation cloud.

2.56 The disturbance created by the underwater burst caused a series of waves to move outward from the center of the explosion across the surface of Bikini lagoon. At 11 seconds after the detonation, the first wave had a maximum height of 94 feet and was about 1,000 feet from surface zero. This moved outward at high speed and was followed by a series of other waves. At 22,000 feet from surface zero, the ninth wave in the series was the highest with a height of 6 feet.

TABLE 5.40

MAXIMUM HEIGHTS (CREST TO TROUGH) AND ARRIVAL TIMES OF WATER WAVES AT BIKINI BAKER TEST

Distance (yards)	330	660	1, 330	2, 000	2, 700	3, 300	4, 000
Wave height (feet)	94	47	24	16	13	11	9
Time (seconds)	11	23	48	74	101	127	154

Figure 5.37. Waves from the BAKER underwater explosion reaching the beach at Bikini, 11 miles from surface zero.

2.58 The base surge at Bikini commenced to form at 10 or 12 seconds after the detonation. The surge cloud, billowing upward, rapidly attained a height of 900 feet, and moved outward at an initial rate of more than a mile a minute. Within 4 minutes the outer radius of the cloud, growing rapidly at first and then more slowly, was nearly 3½ miles across and its height had then increased to 1,800 feet.

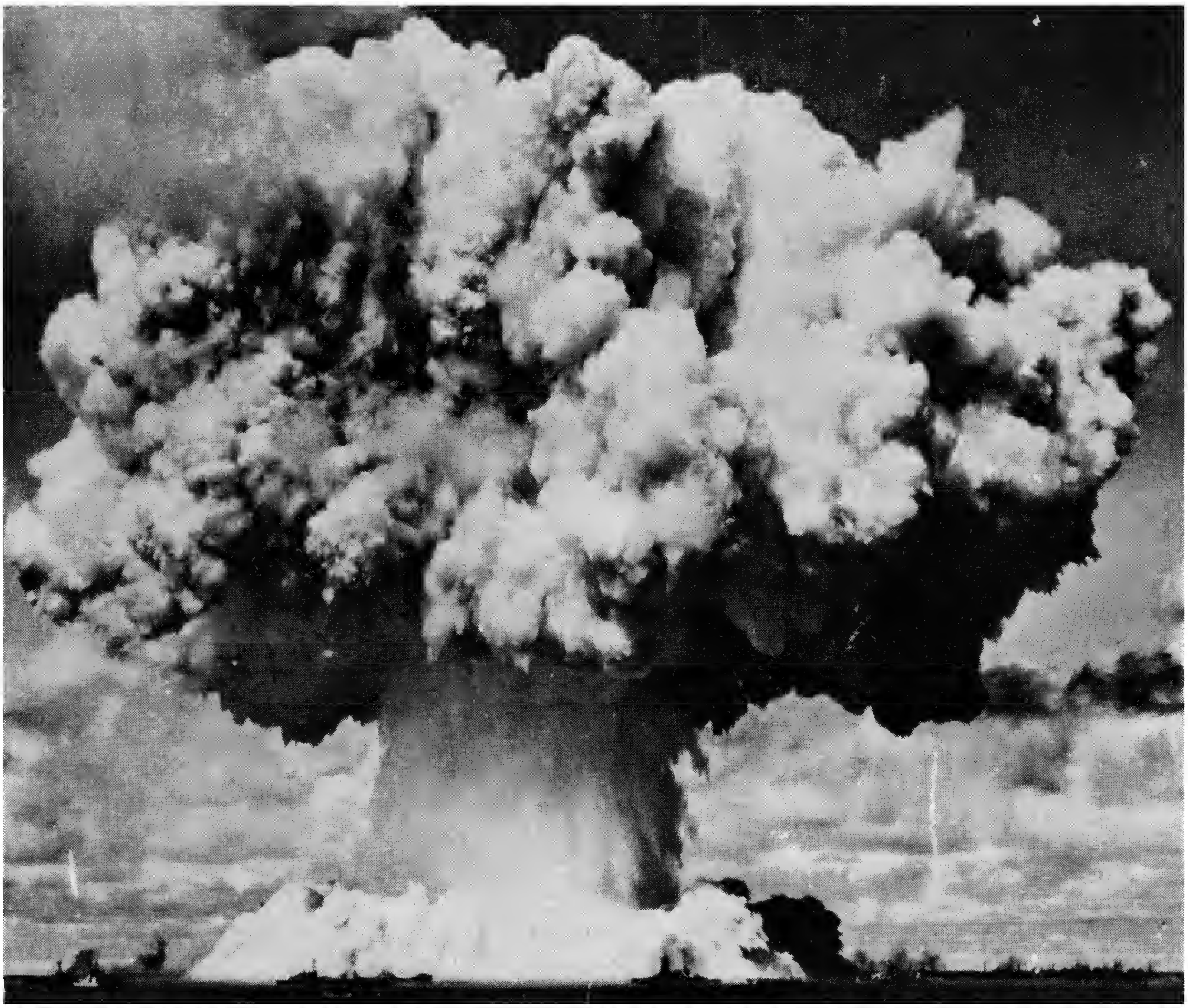


Figure 2.54. The radioactive cloud and first stages of the base surge following

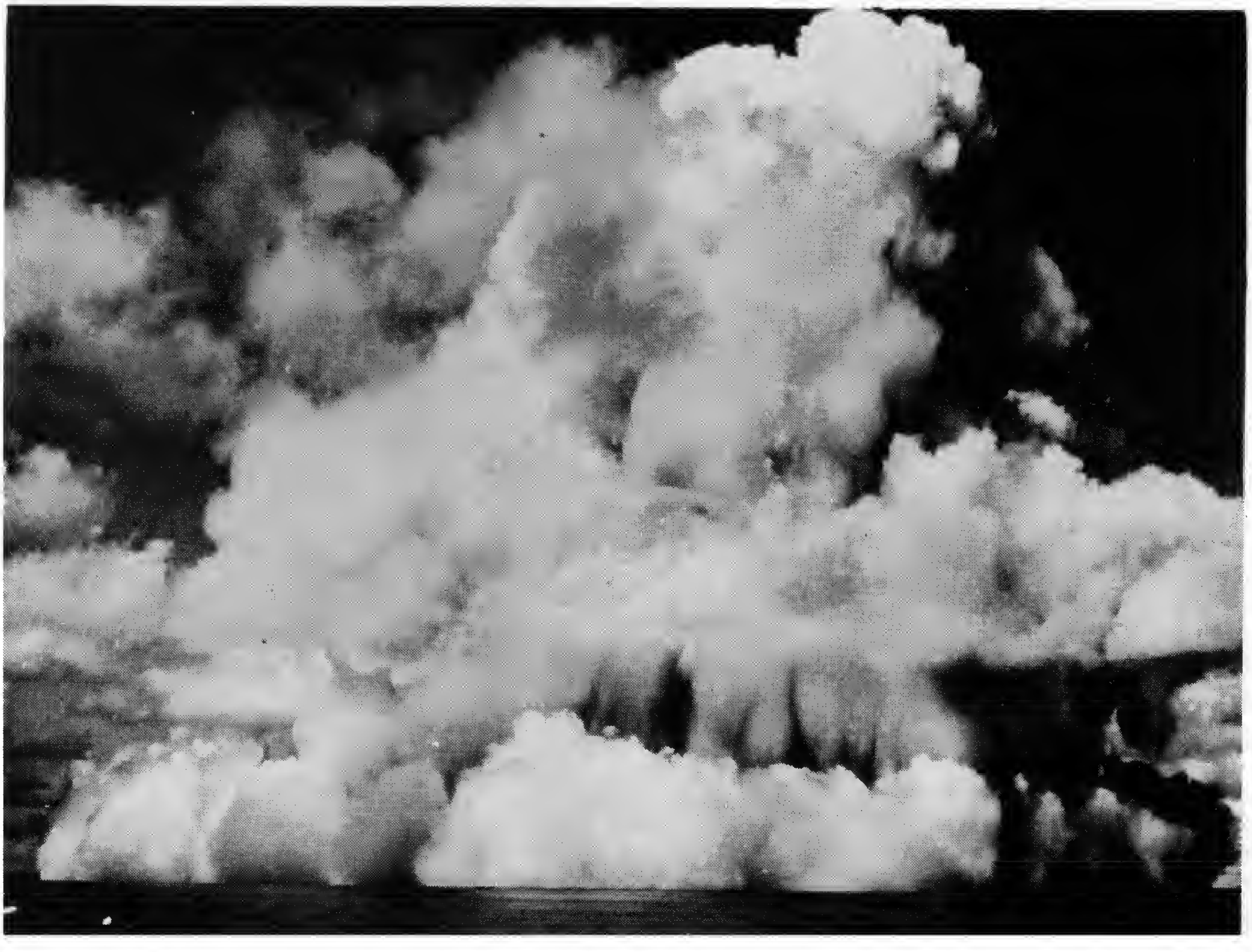
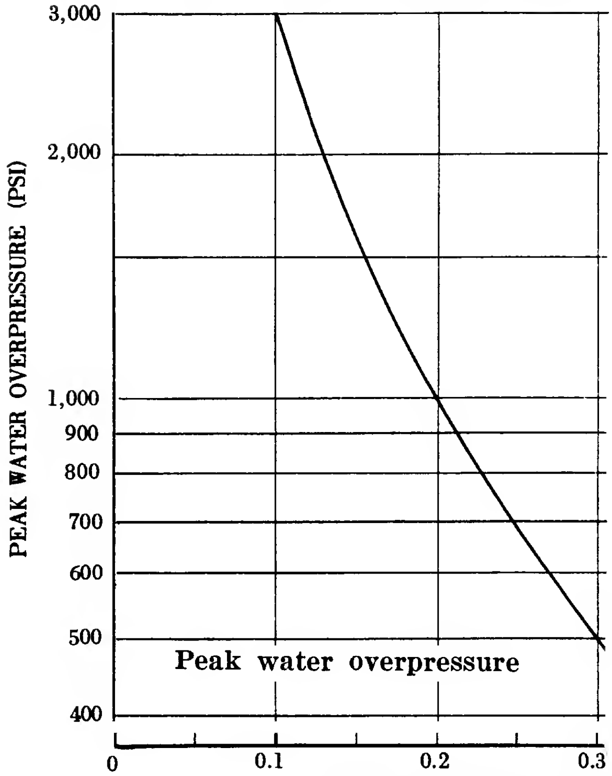
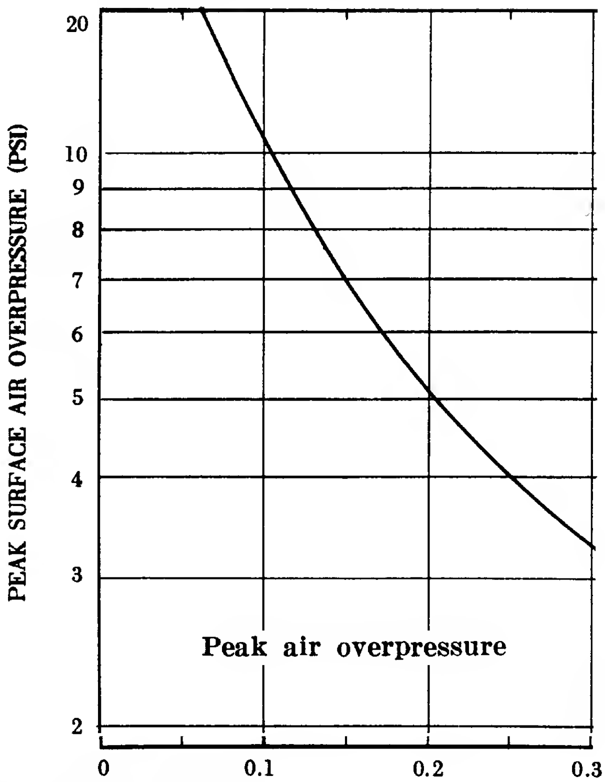


Figure 2.58. The development of the base surge following an underwater explosion.

1-kiloton explosion at mid-depth in water 66 feet deep.





DISTANCE FROM SURFACE ZERO (STATUTE MILES)

Figure 5.52.

Figure 5.53.

Figure 4.101a. The U. S. S. Crittenden after ABLE test; damage resulting was generally moderate (0.47 mile from surface zero).

12 psi peak air overpressure (2,500 ft from Crossroads-Able)

5.32 The damage to the component plates of a ship is dependent mainly on the peak pressure of the underwater shock wave. The same is probably true for the gate structure of canal locks and drydock caissons. Within the range of very high pressures at the shock front, such structures may be expected to sustain appreciable damage. On the other hand, damage to large, rigid subsurface structures, such as harbor installations, is more nearly dependent upon the shock wave impulse.

Underwater Shock Damage: Bikini Experience

5.33 In the shallow, underwater (BAKER) nuclear test at Bikini in July 1946, which was described in Chapter II, some 70 ships of various types were anchored around the point of burst. Although, the explosion was accompanied by an air blast wave of considerable energy, the major damage to the ships in the lagoon was caused by the shock wave transmitted through the water.

5.34 The lethal or sinking shock overpressure in water for all types of ships of fairly substantial construction is expected to be very much the same, probably about 3,000 or 4,000 pounds per square inch, for a shallow underwater burst similar to the BAKER test. Some ships may be expected to sink as a result of an overpressure of 2,000 pounds per square inch, and those which survive will be damaged to such an extent as to render them almost useless. Most vessels will be immobilized at peak pressures down to 1,000 pounds per square inch. At lower pressures most of the damage will be to equipment rather than to the ship plates.

Table 9.108

DIMENSIONS AND DOSE RATE OF CONTAMINATED WATER AFTER THE 20-KILOTON UNDERWATER EXPLOSION AT BIKINI

Time after explosion (hours)	Contaminated area (square miles)	Mean diameter (miles)	Maximum dose rate (roentgens per hour)
4	16. 6	4. 6	3. 1
38	18. 4	4. 8	0. 42
62	48. 6	7. 9	0. 21
86	61. 8	8. 9	0. 042
100	70. 6	9. 5	0. 025
130	107	11. 7	0. 008
200	160	14. 3	0. 0004

Figure 4.100b. Aircraft after tail exposed to nuclear explosion (2.4 psi overpressure).

Figure 6.24a. Forest stand after a nuclear explosion, B damage (3.8 psi overpressure).

110 KT CASTLE-3, 1954, NO FIRESTORM!

Figure 6.24b. Forest stand after a nuclear explosion, C damage (2.4 psi overpressure).

TABLE 6.24

DAMAGE CRITERIA FOR FORESTS

Damage class	Nature of damage	Equivalent hurricane wind velocity (miles per hour)
A & B	Up to 90 percent of trees blown down; remainder denuded of branches and leaves (Fig. 6.24a). (Area impassable to vehicles and very difficult on foot.)	130–140
C	About 30 percent of trees blown down; remainder have some branches and leaves blown off (Fig. 6.24b). (Area passable to vehicles only after extensive clearing.)	90–100
D	Very few trees blown down; some leaves and branches blown off. (Area passable to vehicles.)	60–80

15 megaton Castle-Bravo: the exaggerated effects

7.70 A distinctive feature of the thermal radiation burns was their sharp limitation to exposed areas of the skin facing the center of the explosion. For this reason they were sometimes called "profile burns" (Fig. 7.70). The phenomenon was due to the fact that most of the radiation received had traveled in a straight line from the ball of fire, and so only regions that were directly exposed were affected. A striking illustration of this behavior was that of a man writing before a window. His hands were seriously burned, but his face and neck, which were not covered, suffered only slight burns because the angle of entry of the radiation through the window was such as to place them in partial shadow.

7.71 Although flash burns were largely confined to exposed parts of the body, there were a few cases where such burns occurred through one, and very occasionally more, layers of clothing. Instances of this kind, however, were observed only near to ground zero where fairly large amounts of radiant energy were received. When burns did occur through clothing, these generally involved regions where the clothes were tightly drawn over the skin, at the elbows and shoulders, for example. Such burns may have been due to contact with the hot fabric,

Figure 7.70 Partial protection against thermal radiation produced "profile" burns (1.23 miles from ground zero). The cap was sufficient to protect the top of the head against flash burn.

Figure 7.71. The skin under the areas of contact with clothing is burned. The protective effect of thicker layers can be seen on the shoulders and across the back.

as described in § 7.57, rather than to the direct effect of radiation. Areas over which the clothing fitted loosely, so that an air space separated it from the skin, were generally unharmed by the radiation (Fig. 7.71).

7.72 There were many instances in which burns occurred through black clothing, but not through white material worn by the same individuals (Fig. 7.72). This was attributed to the reflection of thermal radiation by white or other light-colored fabrics, whereas materials of dark color absorbed radiation, became hot, and so caused contact burns. In some cases black outer clothing actually burst into flame and ignited the undergarments, so that flame burns resulted. It should be recalled, however, as mentioned in § 7.57, that white clothing does not always necessarily provide protection against thermal radiation. Some materials of this kind transmit enough radiation to permit flash burning of the skin to occur.

OBFUSCATION: NO NUMBERS FOR PROTECTIVE FACTORS!!

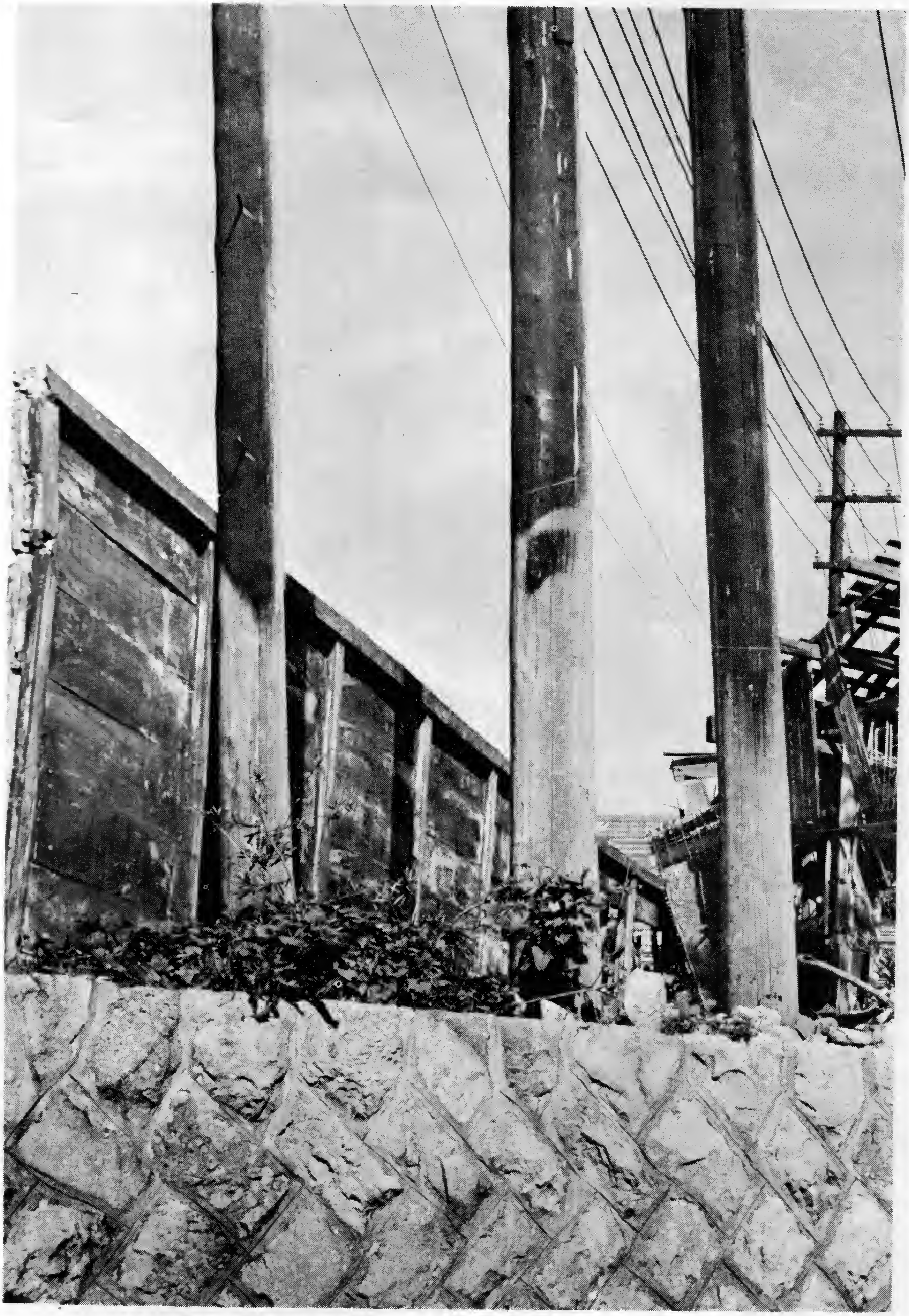


Figure 7.73b. Flash burns on wooden poles (1.17 miles from ground zero at Nagasaki). The uncharred portions were protected from thermal radiation by a fence.

11.39 It is an interesting fact that among the survivors in Hiroshima and Nagasaki, eye injuries directly attributable to thermal radiation appeared to be relatively unimportant. There were many cases of temporary blindness, occasionally lasting up to 2 or 3 hours, but more severe eye injuries were not common.

11.40 The eye injury known as keratitis (an inflammation of the cornea) occurred in some instances. The symptoms, including pain caused by light, foreign-body sensation, lachrymation, and redness, lasted for periods ranging from a few hours to several days. Among 1,000 cases, chosen at random, of individuals who were in the open, within some 6,600 feet (1.25 miles) of ground zero at the time of the explosions, only 42 gave a history of keratitis coming on within the first day. Delayed keratitis was reported in 14 additional cases, with symptoms appearing at various times up to a month or more after the explosion. It is possible that nuclear radiation injury, which is associated with delayed symptoms, as will be seen below, may have been a factor in these patients.

11.41 Investigators have reported that in no case, among the 1,000 examined, was the thermal radiation exposure of the eyes apparently

sufficient to produce permanent opacity of the cornea. This observation is surprising in view of the severe burns of the face suffered by many of the patients. Thus, in approximately one-quarter of the cases studied there had been facial skin burns and often burning of the eyebrows and eyelashes. Nevertheless, some three years later the corneas were normal. No persons in the survey group developed permanent central scotomata (blind spots), although several stated that they were looking in the direction of the bomb at the time of the explosion.

11.42 Several reasons have been suggested for the scarcity of severe eye injuries in Japan. For example, it seems probable that the blink reflex was rapid enough to provide significant protection. Another possible explanation is that the recessed position of the eyes and, in particular, the overhanging upper lids served to decrease the direct exposure to thermal radiation. On the basis of probability, only a small proportion of individuals would actually be facing the explosion and owing to the bright sunlight the pupils of the eyes would be small, thus decreasing the exposed area.

7.82 The fact that accumulations of ignitable trash close to a wooden structure represent a real fire hazard was demonstrated at the nuclear tests carried out in Nevada in 1953. In these tests, three miniature wooden houses, each having a yard enclosed with a wooden

fence, were exposed to 12 calories per square centimeter of thermal radiation. One house, at the left of Fig. 7.82, had weathered siding showing considerable decay, but the yard was free from trash. The next house also had a clean yard and, further, the exterior siding was well maintained and painted. In the third house, at the right of the photograph, the siding, which was poorly maintained, was weathered, and the yard was littered with trash.

7.83. The state of the three houses after the explosion is seen in Fig. 7.83. The third house, at the right, soon burst into flame and was burned to the ground. The first house, on the left, did ignite but it did not burst into flame for 15 minutes. The well maintained house in the center with the clean yard suffered scorching only. It is of interest to recall that the wood of a newly erected white-painted house exposed to about 25 calories per square centimeter was badly charred but did not ignite (Fig. 7.34b).

7.84 The value of fire-resistive furnishing in decreasing the number of ignition points was also demonstrated in the 1953 tests. Two identical, sturdily constructed houses, each having a window 4 feet by 6 feet facing the point of burst, were erected where the thermal radiation exposure was 17 calories per square centimeter. One of the houses contained rayon drapery, cotton rugs, and clothing, and, as was expected, it burst into flame immediately after the explosion and burned completely. In the other house, the draperies were of vinyl plastic, and rugs and clothing were made of wool. Although more ignition occurred, the recovery party, entering an hour after the explosion, was able to extinguish fires.

Figure 7.82. Wooden test houses before exposure to a nuclear explosion, Nevada Test Site.

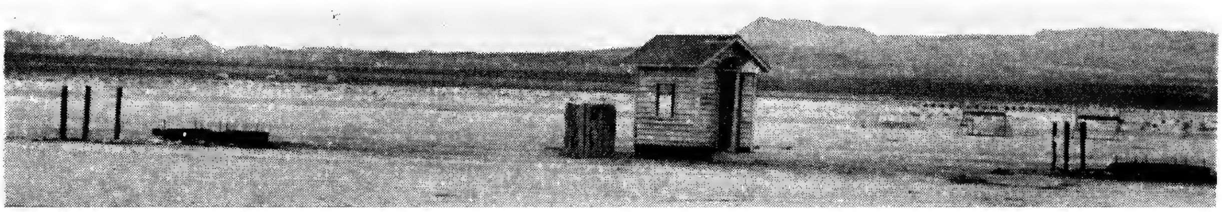


Figure 7.83. Wooden test houses after exposure to the nuclear explosion.

 OBFUSCATION!!

4.4 Many buildings, that at a distance appeared to be sound, were found on close inspection to be damaged and gutted by fire. This was frequently an indirect result of blast action. In some instances the thermal radiation may have been responsible for the initiation of fires, but in many other cases fires were started by overturned stoves and furnaces and the rupture of gas lines. The loss of water pressure by the breaking of pipes, mainly due to the collapse of buildings, and other circumstances arising from the explosions, contributed greatly to the additional destruction by fire.

PROOF THAT FIRES WERE CAUSED BY CHARCOAL STOVES:

A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. USSBS 92v2 p4

GROUND ZERO

Figure 4.5. Debris after the atomic bomb explosion at Hiroshima.

ORIGIN AND SPREAD OF FIRES IN JAPAN

7.91 Definite evidence was obtained from Japanese observers that the thermal radiation caused thin, dark cotton cloth, such as the black-out curtains that were in common use during the war, thin paper, and dry, rotted wood to catch fire at distances up to 3,500 feet (0.66 mile) from ground zero (about 35 calories per square centimeter).

DISTANCE WAS ACTUALLY ONLY 2500 FT FROM GROUND ZERO!

LIE!!

7.94 It is not known to what extent thermal radiation contributed to the initiation of fires in the nuclear bombings in Japan. It is possible that, up to a mile or so from ground zero, some fires may have originated from secondary causes, such as upsetting of stoves,

tion of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons

3200 ft from AIR zero = 2500 ft from ground z! USSBS 92v2 p4

THE UNITED STATES STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

(USSBS Report 92)

Volume II

Physical Damage Division

Dates of Survey:

14 October–26 November 1945

Date of Publication

May 1947

4. The city, consisting principally of Japanese domestic structures, was highly combustible and densely built up. Sixty-eight percent of the 13-square-mile city area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 94 percent of it being 27 to 42 percent built up. All the large industrial plants were located on the south and southeast edges of the city.

8. Evidence relative to ignition of combustible structures and materials by directly radiated heat from the atomic bomb and other ignition sources was obtained by interrogation and visual inspection of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion. Dark clothing was scorched and, in some cases, was reported to have burst into flame from flash heat. A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. Other sources of secondary fire were industrial-process fires and electric short circuits.

9. There had been practically no rain in the city for about 3 weeks. The velocity of the wind on the morning of the atomic-bomb attack was not more than 5 miles per hour.

10. Hundreds of fires were reported to have started in the center of the city within 10 minutes after the explosion.

4

PHOTO 36 IX. Shows partly burned coat of boy who was in open near City Hall (Building 28) 3,800 feet from AZ.

(8) Scores of persons throughout all sections of the city were questioned concerning the ignition of clothing by the flash from the bomb. Replies were consistent that white silk seldom was affected, although black, and some other colored silk, charred and disintegrated. Numerous instances were reported in which designs in black or other dark colors on a white silk kimono were charred so that they fell out, but the white part was not affected. These statements were confirmed by United States medical officers who had been able to examine a number of kimonos available in a hospital. Ten school boys were located during the study who had been in school yards about 6,200 feet east and 7,000 feet west, respectively, from AZ. These boys had flash burns on the portions of their faces which had been directly exposed to rays of the bomb. The boys' stories were consistent to the effect that their clothing, apparently of cotton materials, "smoked," but did not burst into flame. Photo 36 shows a boy's coat that started to smolder from heat rays at 3,800 feet from AZ.

(3300 from GZ)

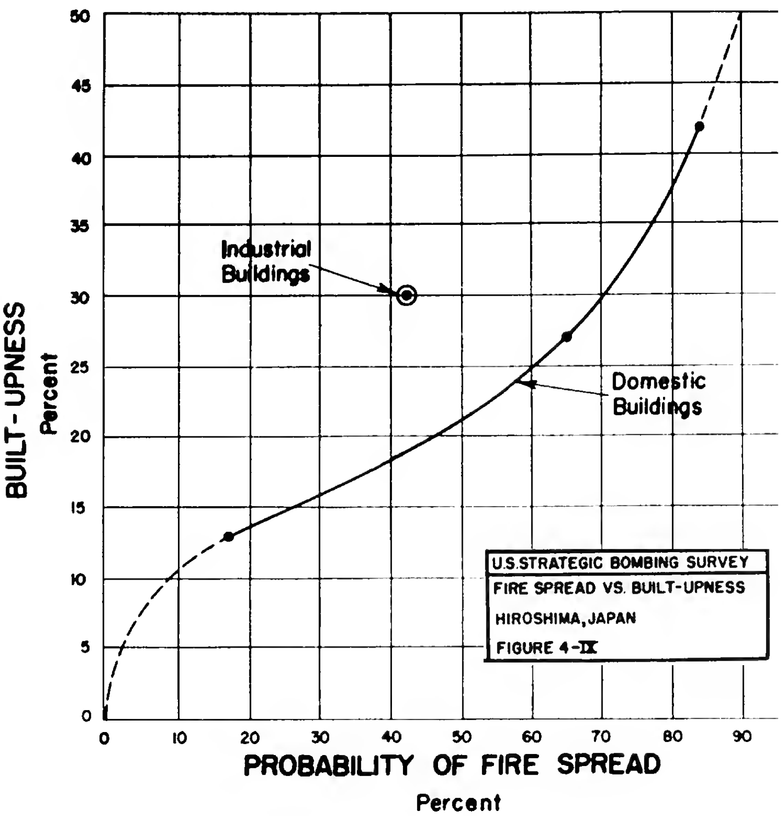
24

D. THE CONFLAGRATION

1. Start of Fire

b. Direct Ignition by the Atomic Bomb. (1) Six persons were found who had been in reinforced-concrete buildings within 3,200 feet of AZ at the time of the explosion and who stated that black cotton black-out curtains were blazing a few seconds later. In two cases it was stated that thin rice paper on desks close to open windows facing AZ also burst into flame immediately, although heavier paper did not ignite. No incidents were recounted to the effect that furniture or similar objects within buildings were ignited directly by radiated heat from the bomb.

21



(4) It was reported that a cotton black-out curtain at an unprotected window in the east stair tower of Building 85 (3,800 feet from AZ) smoked and was scorched by radiated heat from the bomb but it did not burst into flames.

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(5) A man who was in the third story of building 26 (3,000 feet from AZ) stated that radiated heat from the bomb ignited cotton black-out curtains at unprotected windows in the west wall and thin rice paper on desks.

47

(10) Fire fighting with water buckets was reported inside only four buildings (24, 33, 59, and 122) and probably prevented extensive fire damage in them. In Building 24, fire was started in contents of a room at the southwest corner of the second story by sparks from trees on the south side about 1½ hours after the attack. Men inside the building extinguished the fire and probably prevented further damage in the first and second stories (Photo 85). A little later, contents in the third story were ignited by sparks from the outside and were totally damaged. This fire was beyond control before it was discovered, but did not spread downward through open stairs. At Building 33, sparks from the west exposure, which burned in early evening, set fire to black-out curtains in the west wall and to waste paper in the fourth story of the northwest section of the building. Twenty persons were on guard in the building awaiting such an occurrence and the fires were quickly extinguished while in the incipient stage. At Building 59 sparks from the south exposure ignited a few pieces of furniture in the first and third stories and black-out curtains in the first story about 2 hours after the attack. These fires were extinguished by men inside and negligible damage resulted. A few window frames in the east and west walls and 2 or 3 desks in the first story of Building 122 were ignited by radiated heat and sparks from the west and northeast exposures. These fires were extinguished quickly and damage was negligible.

58

A. SUMMARY

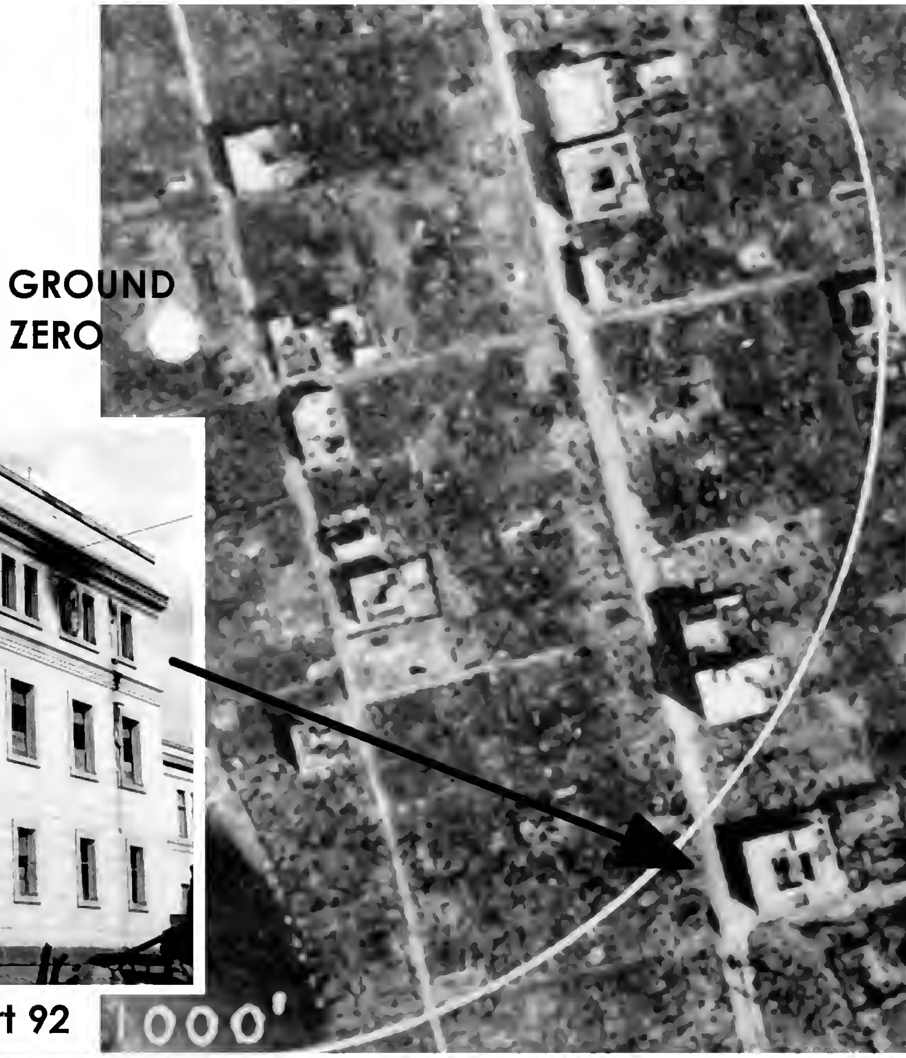
4. The mean areas of effectiveness (MAE) of the atomic bomb for structural damage about ground zero (GZ) and the radii of the MAE's for the several classes of buildings present were computed to be as follows:

	MAE's in square miles	Radii of MAE's in feet
Multistory, earthquake-resistant	0.03	500
Multistory, steel- and reinforced-concrete frame (including both earthquake- and non-earthquake-resistant construction)	.05	700
1-story, light, steel-frame	3.4	5,500
Multistory, load-bearing, brick-wall	3.6	5,700
1-story, load-bearing, brick-wall	6.0	7,300
Wood-frame industrial-commercial (dimension-timber construction)	8.5	8,700
Wood-frame domestic buildings (wood-pole construction)	9.5	9,200
Residential construction	6.0	7,300

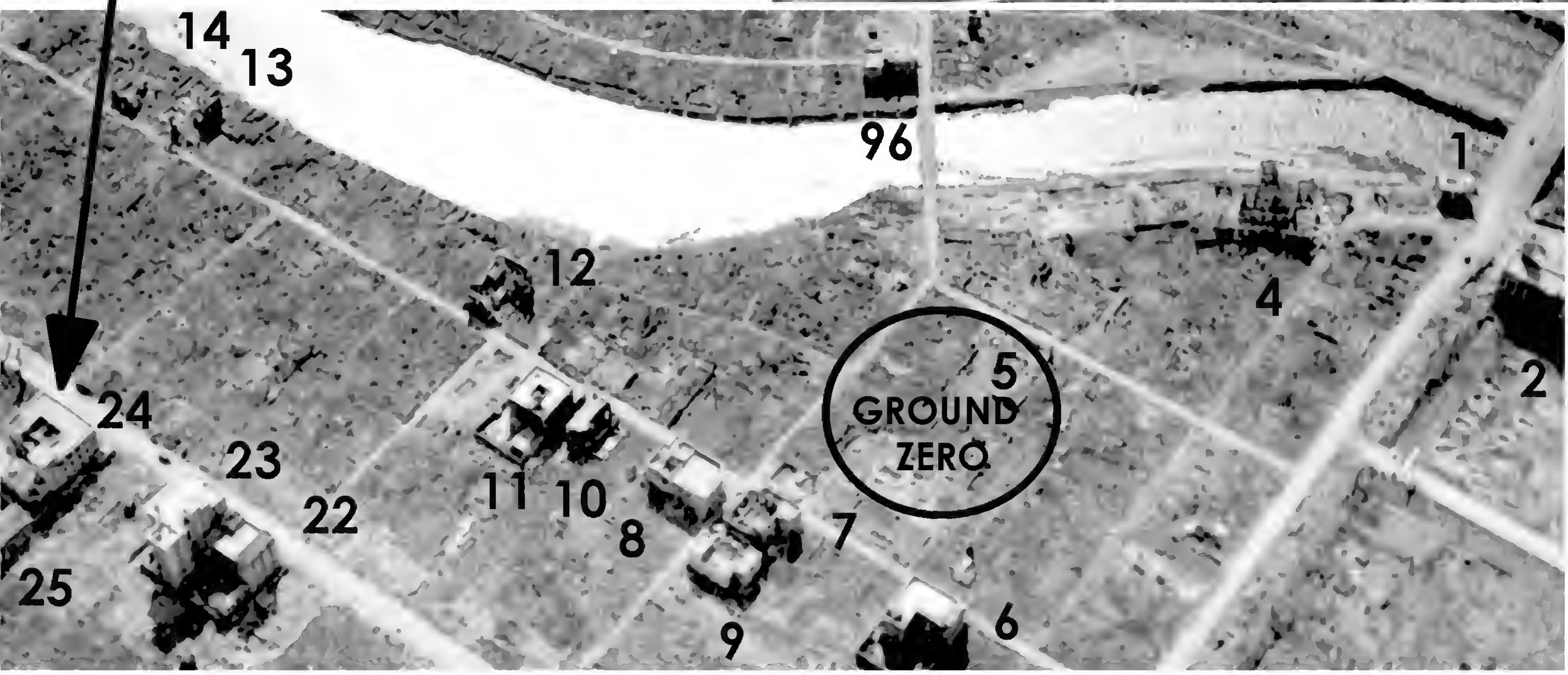
96

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.



U.S. Strategic Bombing Survey report 92



S. Glasstone, The Effects of Nuclear Weapons, 1957:

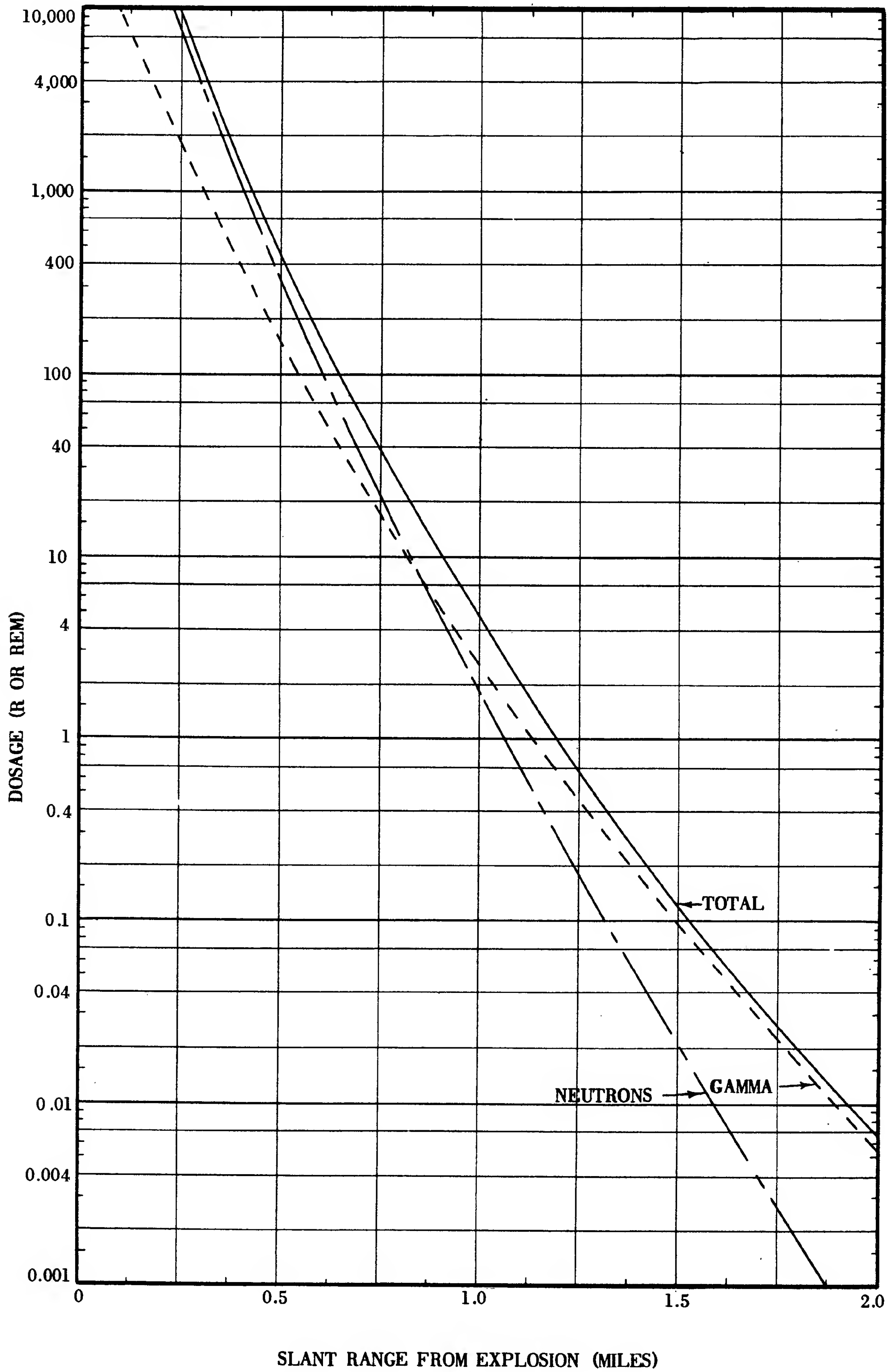


Figure 8.80. Comparison of neutron and initial gamma radiation dosages for a 1-kiloton air burst.

Note that a city skyline PF of 100 would reduce INR at 0.25 mi. to just 100 R, before further shielding from being in a building!

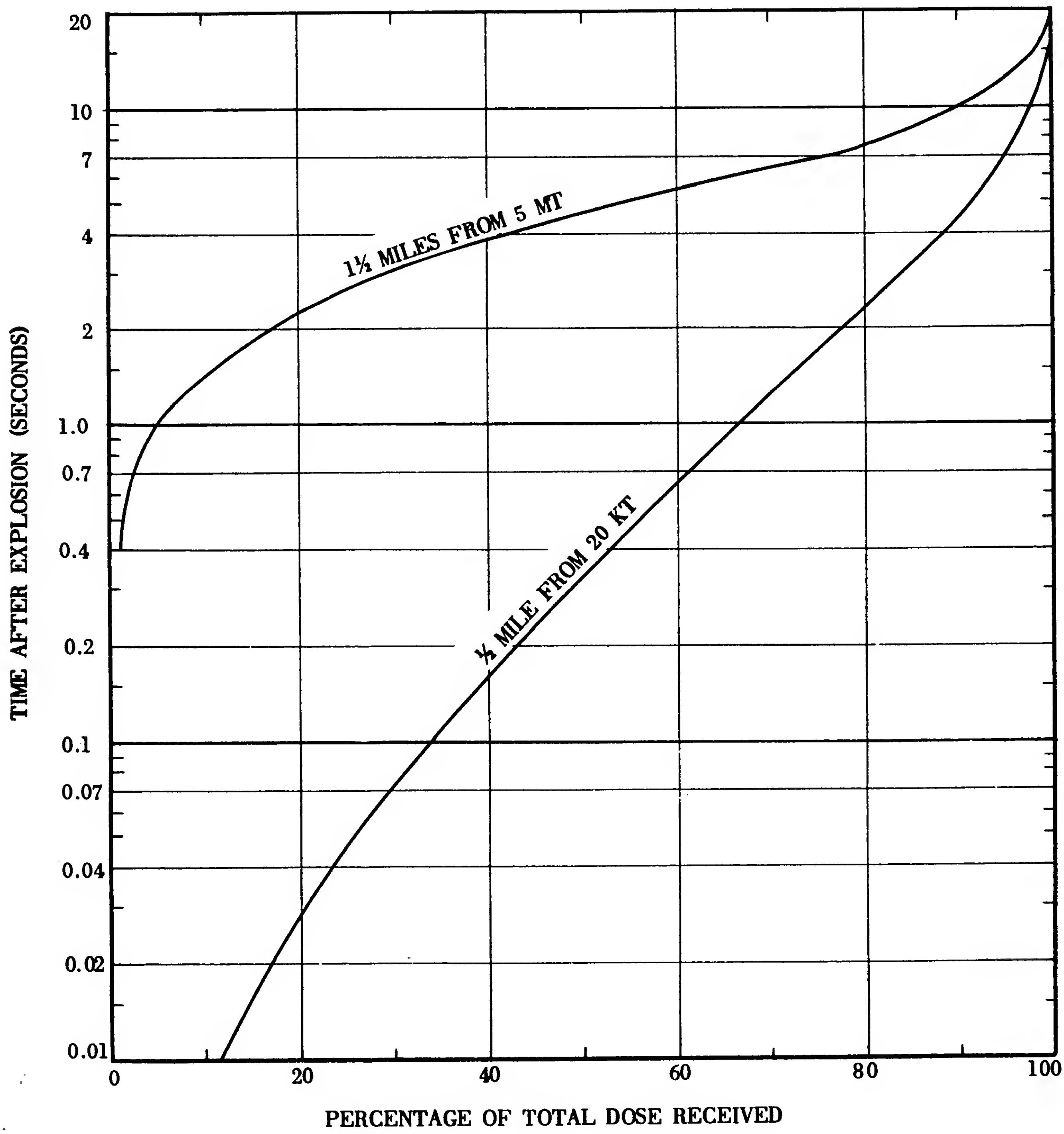


Figure 8.51. Percentage of total dosage of initial gamma radiation received at various times after explosion.

8.52 It would appear, therefore, that if some shelter could be obtained, e. g., by falling prone, as recommended in § 7.54, preferably behind a substantial object, within a second of seeing the bomb flash, in certain circumstances it might make the difference between life and death. The curves in Fig. 8.51 show that for a bomb of high energy the gamma radiation may be emitted more slowly, especially in the early stages immediately following the explosion, than for one of lower energy. Avoidance of part of the initial gamma ray dose would appear to be more practicable for explosions of higher energy yields.

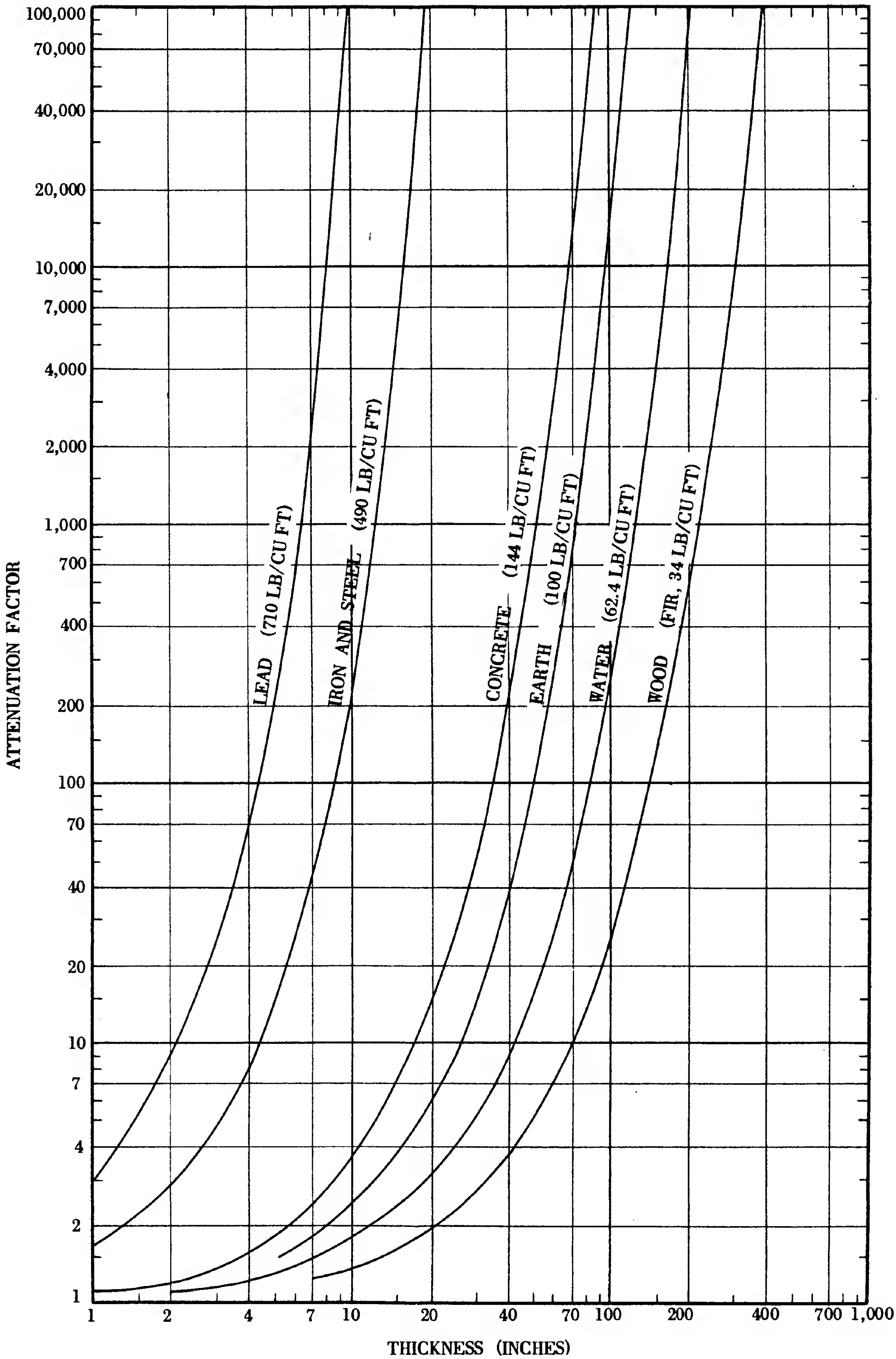


Figure 8.47. Attenuation of initial gamma radiation.

4.5 MeV gamma ray energy assumed (footnote: page 402)

p. 367: Shielding Against Neutrons A thickness of 10 inches of concrete, for example, will decrease the neutron dose by a factor of about 10, and 20 inches by a factor of roughly 100.

FAILS TO QUANTIFY THE RELATIVELY SMALL DOSES FROM SCATTERED RADIATIONS WHERE THE FRACTION OF SKY EXPOSED TO A TARGET IS MINIMAL (E.G. NARROW TRENCH)

(SCATTERED RADIATION IS ALSO OF LOWER ENERGY)

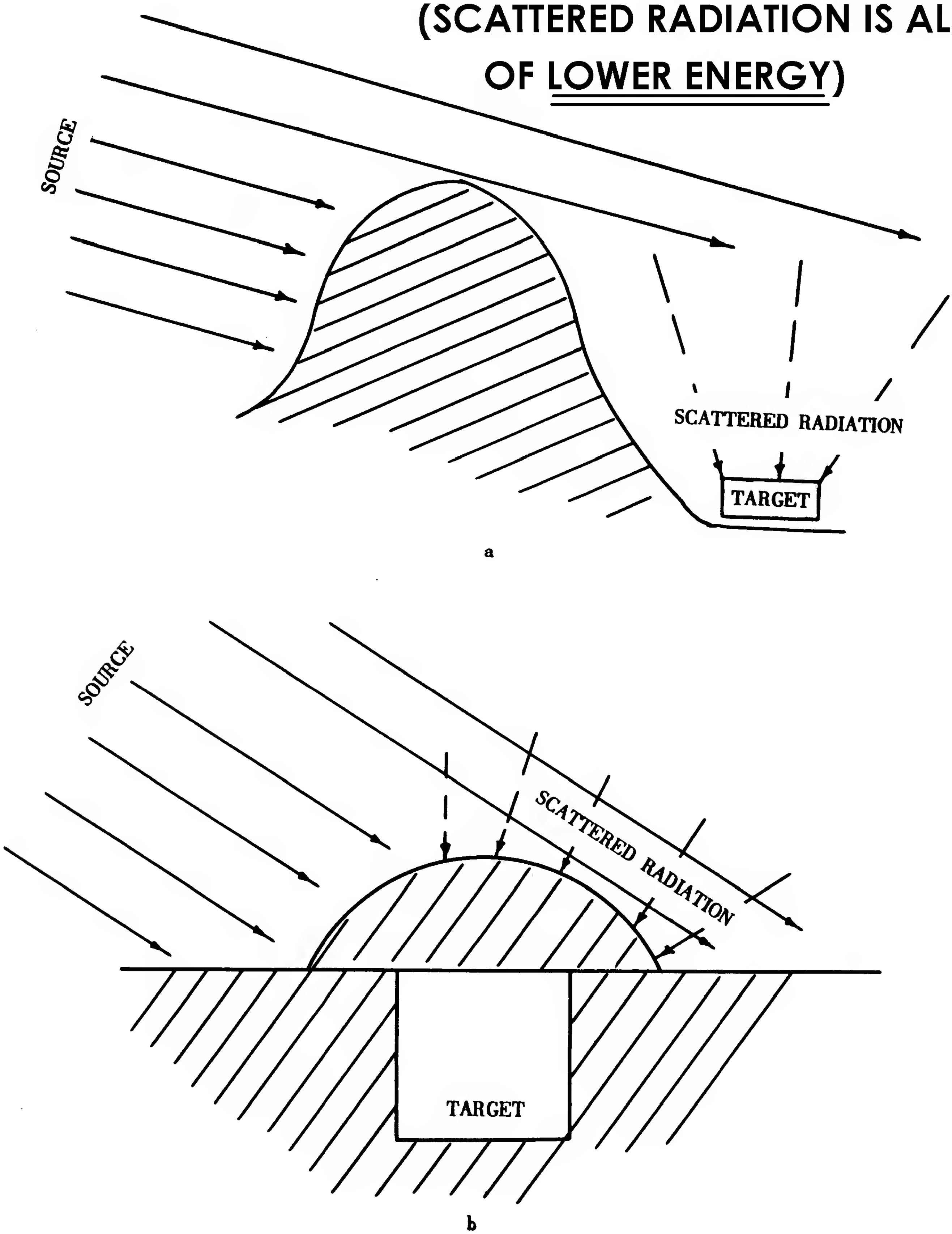


Figure 8.49a. Target exposed to scattered gamma radiation.
Figure 8.49b. Target shielded from scattered gamma radiation.

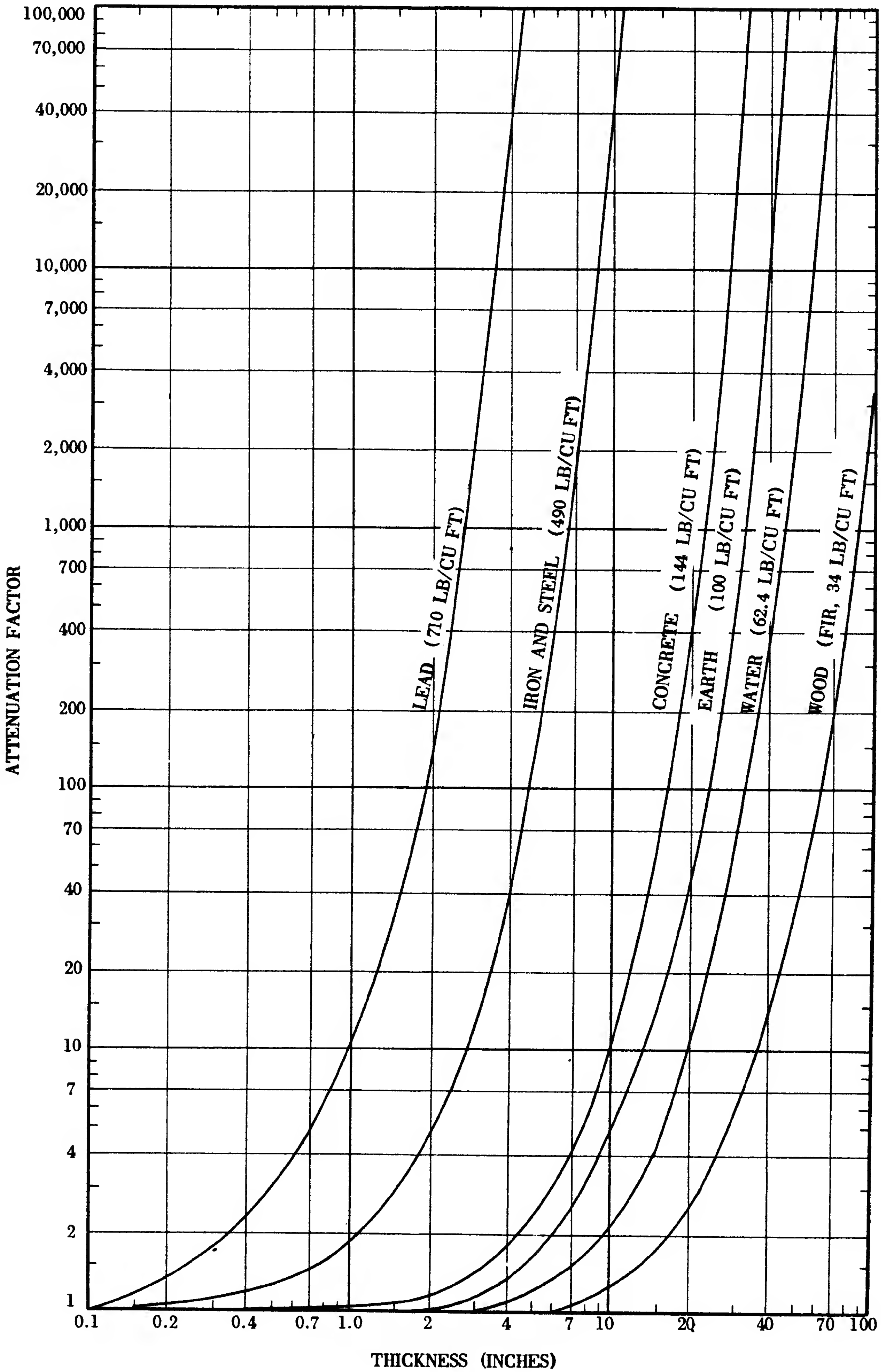


Figure 9.36. Attenuation of fission product radiation.

0.7 MeV energy

9.37 From the practical standpoint, it is of interest to record the attenuation factors that might be expected inside various structures. Two factors are responsible for this attenuation. First, there is the effect of distance, because the source of the radiation will be mostly outside, e. g., on the roof or in the street; and second, there is partial absorption of the radiation by the roof and walls. The approximate values given in Table 9.37 have been estimated partly from calculations and partly on the basis of field measurements. It will be noted that in the basement of a frame house the residual gamma radiation is reduced to about one-tenth of its value outside the house. A 3-foot layer of earth attenuates the radiations to one-thousandth (or less) of the intensity it would otherwise have at the same location.

Table 9.37

ESTIMATED ATTENUATION FACTORS IN STRUCTURES FOR RESIDUAL GAMMA RADIATION

Type of Structure	Approximate attenuation factor
Frame house:	
First floor	2
Basement	10
Multistory, reinforced concrete:	
Lower floors (away from windows)	10
Basement (surrounded by earth)	*1, 000
Shelter below grade:	
3 feet of earth	*1, 000

*Or more.

RAPID APPROACH TO INFINITY-TIME DOSE!

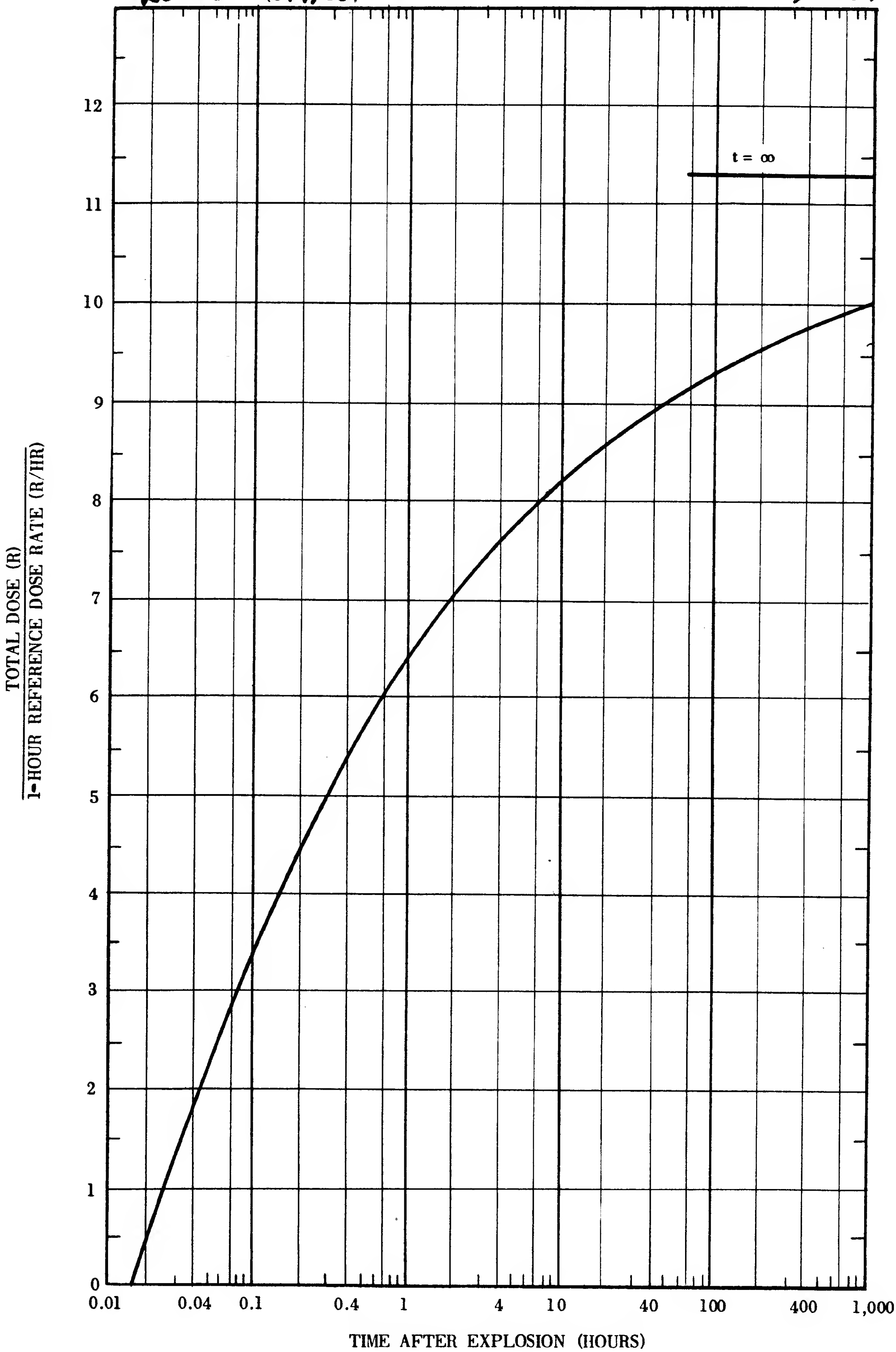


Figure 9.12. Accumulated total dose of residual radiation from fission products from 1 minute after the explosion.

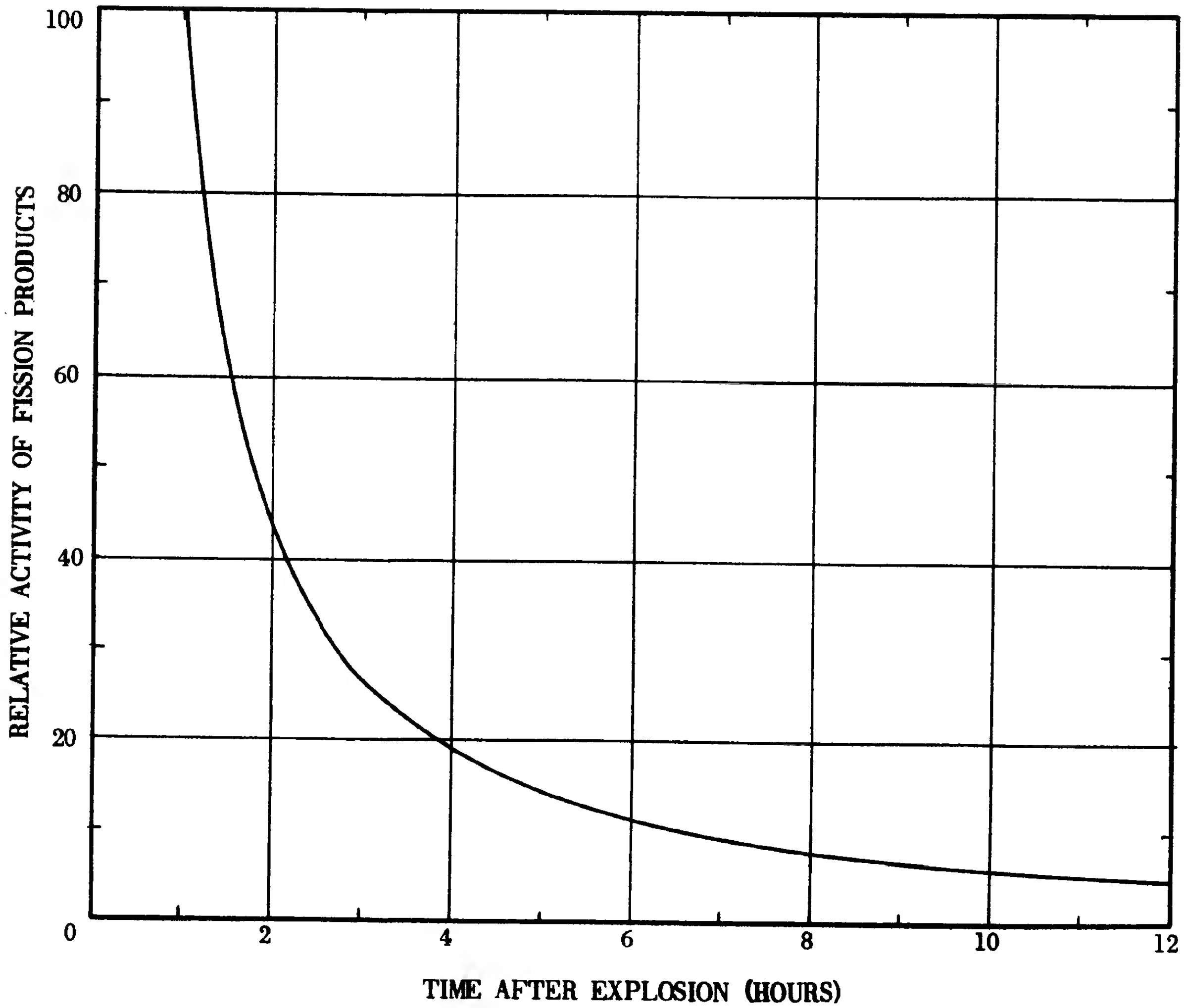


Figure 1.50. Rate of decay of fission products after a nuclear explosion (activity is taken as 100 at 1 hour after the detonation).

Alpha-Particle Activity

1.51 In addition to the beta-particle and gamma-ray activity due to the fission products, there is another kind of residual radioactivity that should be mentioned. This is the activity of the fissionable material, part of which, as noted in §1.18, remains after the explosion. Both uranium and plutonium are radioactive, and their activity consists in the emission of what are called "alpha particles". These are a form of nuclear radiation, since they are emitted from atomic nuclei; but they differ from the beta particles arising from the fission products in being much heavier and carrying a positive electrical charge. Alpha particles are, in fact, identical with the nuclei of helium atoms.

1.52 Because of their greater mass and charge, alpha particles are much less penetrating than beta particles and gamma rays of the same energy. Thus, very few alpha particles from radioactive sources can travel more than 1 to 3 inches in air before being stopped. It is doubtful whether these particles can get through the unbroken skin, and they certainly cannot penetrate clothing. Consequently, the uranium

(or plutonium) present in the bomb residues do not constitute a hazard if they are outside the body. However, if plutonium, in particular, enters the body in sufficient quantity, by ingestion, inhalation, or through skin abrasions, the effects may be serious.

Fusion (Thermonuclear) Reactions

1.53 Energy production in the sun and stars is undoubtedly due to fusion reactions involving the nuclei of various light (low atomic weight) atoms. From experiments made in laboratories with cyclotrons and similar devices, it was concluded that the fusion of isotopes of hydrogen was possible. This element is known to exist in three isotopic forms, in which the nuclei have masses of 1, 2, and 3, respectively. These are generally referred to as hydrogen (H^1), deuterium (H^2 or D^2), and tritium (H^3 or T^3). All the nuclei carry a single positive charge, i. e., they all contain one proton, but they differ in the number of neutrons. The lightest (H^1) nuclei (or protons) contain no neutrons; the deuterium (H^2) nuclei contain one neutron, and tritium (H^3) nuclei contain two neutrons.

1.54 Several different fusion reactions have been observed among the nuclei of the three hydrogen isotopes, involving either two similar or two different nuclei. In order to make these reactions occur to an appreciable extent, the nuclei must have high energies. One way in which this energy can be supplied is by means of a charged-particle accelerator, such as a cyclotron. Another possibility is to raise the temperature to very high levels. In these circumstances the fusion processes are referred to as "thermonuclear reactions," as mentioned earlier.

1.55 Four thermonuclear fusion reactions appear to be of interest for the production of energy because they are expected to occur sufficiently rapidly at realizable temperatures.[4] These are:

$$H^2+H^2=He^3+n+3.2\text{ Mev}$$
$$H^2+H^2=H^3+H^1+4\text{ Mev}$$
$$H^3+H^2=He^4+n+17\text{ Mev}$$
$$H^3+H^3=He^4+2n+11\text{ Mev},$$

where He is the symbol for helium and n (mass=1) represents a neutron. The energy liberated in each case is expressed in Mev (million electron volt) units.[5] Without going into details, it may be

[4] L. N. Ridenour, *Scientific American, 182,* No. 3, 11 (1950); H. Bethe, *ibid., 182,* No. 4, 18 (1950).

[5] An electron volt is the energy that would be acquired by a unit electric charge, i. e., an electron, if accelerated by a potential of 1 volt. The million electron volt unit, i. e., 1 Mev, is one million times as large, and is equivalent to 1.6×10^{-6} erg or 1.6×10^{-13} joule.

stated that the fission of a nucleus of uranium or plutonium, having a weight of nearly 240 atomic mass units, releases about 200 Mev. This may be compared with an average of about 24.2 Mev obtained from the fusion of 5 deuterium nuclei with a weight of 10 mass units. Weight for weight, therefore, the fusion of deuterium nuclei would produce nearly three times as much energy as the fission of uranium or plutonium.

Contamination of Areas

9.99 In contaminated agricultural areas, the hazard to workers could be reduced by turning over the earth, so as to bury the fallout particles.

Experience With Fallout as an Internal Hazard

11.115 The fallout accompanying the nuclear air bursts over Japan was so insignificant that no information was available concerning the potentialities of fission products and other bomb residues as internal sources of radiation. Following the incident in the Marshall Islands in March 1954, however, data of considerable interest were obtained. Because they were not aware of the significance of the fallout, many of the inhabitants ate contaminated food and drank contaminated water from open containers for periods up to 2 days or so.

11.116 Internal deposition of fission products resulted mainly from ingestion rather than inhalation for, in addition to the reasons given above, the radioactive particles in the air settled out fairly rapidly, but contaminated food, water, and utensils were used all the time. The belief that ingestion was the chief source of internal contamination was supported by the observations on chickens and pigs made soon after the explosion. The gastro-intestinal tract, its contents, and the liver were found to be more radioactive than lung tissue.

11.117 From radiochemical analysis of the urine of the Marshallese subjected to the fallout, it was possible to estimate the body burden, i. e., the amounts deposited in the tissues, of various isotopes. It was found that iodine–131 made the major contribution to the activity at the beginning, but it soon disappeared because of its relatively short radioactive half-life (8 days).

11.118 No elements other than iodine, strontium, barium, and the rare earth group were found to be retained in appreciable amounts in the body.

Page 450 notes that despite the 30 years radioactive "half life" of Cesium-137, it iwas eliminated from humans with a real (biological) "half life" of just 140 days when ingested!

11.120 In spite of the fact that the Marshallese people lived under conditions where maximum probability of contamination of food and water supplies existed, and that they took no steps to protect themselves in any way, the degree of internal hazard due to the fallout was small. There seems to be little doubt, therefore, that, at least as far as short term effects are concerned, the radiation injury by fallout due to internal sources is quite minor in comparison with that due to the external radiation. If reasonable precautions are taken, as will be described in Chapter XII, the short term, internal hazard can probably be greatly reduced.

Long-Term Internal Hazard

11.121 Apart from the possible long-term effects of radioactive material that has been inhaled or ingested and subsequently eliminated, about which little is yet known, there has been some speculation concerning the relatively long lived strontium-90, to which reference was made in Chapter X. Perhaps because one of the predecessors

of strontium-90, namely krypton-90, is a gas, the initial fission products, especially those deposited in the region of the more-or-less immediate fallout, are somewhat depleted in this isotope of strontium. In any event, to judge from the experience with the inhabitants of the Marshall Islands, the probability that strontium will be taken up and held firmly in the body as a result of inhalation or ingestion of local fallout particles is not great. The possibility that strontium-90 may be absorbed over the course of time in certain foods is, however, a different matter.

GENETIC EFFECTS OF RADIATION

Spontaneous and Induced Mutations

11.123 The genetic effects of radiation are effects of a long-term character which produce no visible injury in the exposed individual but may have notable consequences in future generations. These effects differ from most other changes produced by nuclear radiation in that they appear to be cumulative and, to a great extent, independent of the dose rate. In other words, the extent of the genetic effects depends upon the total radiation dose received and not on whether the exposure is of short duration or spread over many years. Thus, as far as genetic changes are concerned, it is largely immaterial whether the radiation dose is chronic or acute. - **WRONG! Disproved**

10.16 Genetic effects due to strontium-90 are relatively insignificant. In the first place, owing to their very short range in the body, the beta particles from this isotope in the skeleton do not penetrate to the reproductive organs. Further, the intensity of the secondary radiation (bremsstrahlung) produced by the beta particles is low. Finally, the amount of strontium-90 in soft tissue, from which the beta particles might reach the reproductive organs, is small and may be neglected in this regard.

Transfer of Strontium-90 from Soil to the Human Body

10.17 Since most of the strontium-90 is ultimately brought to earth by rain or snow, it will make its way into the soil and eventually into the human body through plants. At first thought, it might appear that the ratio of strontium to calcium in man would become similar to that in the soil from which he obtains his food. Fortunately, however, several processes in the chain of biological transfer of these elements from soil to the human body operate collectively to decrease the quantity of strontium-90 that is stored in man. These transfer processes include the following stages: (1) soil to plant, (2) plant to animal, and (3) animal to man. A certain proportion of calcium (and strontium) is obtained directly from plants, e. g., fruits and vegetables, but this is not very large, as will be seen shortly. Experiments show that in each of the three stages mentioned there is a natural discrimination in favor of calcium and against strontium, so that the ratio of strontium-90 to calcium in the human body is less than that in the top few inches of the soil.

10.18 Several factors make it difficult to generalize concerning the ratio of strontium-90 to calcium in the plant compared to that in the soil in which it grows. First, plants obtain most of their minerals through their root systems, but such systems vary from plant to plant, some having deep roots and others shallow roots. Most of the strontium-90 in undisturbed soil has been found close to the surface, so that the uptake of this isotope may be expected to vary with the growth habit of the plant. Second, although strontium and calcium, because of their chemical similarity, may be thought of as competing for entry into the root system of plants, not all of the calcium in soil is always available for assimilation. There are natural calcium compounds in soil which are insoluble and are not available as plant food until they have been converted to other compounds by agencies such as humic acid. Most of the strontium-90 in the present world-wide fallout, however, is in a water-soluble form. Third, although plants can sub-

stitute strontium for calcium, to some extent, it is apparent that they prefer calcium. Fourth, in addition to the strontium-90 which plants obtain from the soil, growing plants will also gather a certain amount of strontium-90 from fallout deposited directly on the surface of the plant. The experimental data at present available, however, indicate that the strontium-90/calcium ratio in plants is generally somewhat less than in the soil from which they were grown.

10.19 As the next link in the chain, animals consume plants as food, thereby introducing strontium-90 into their bodies. Once again, the evidence indicates that natural discrimination factors result in a strontium-90/calcium ratio in the edible animal products that is less than in the animal's feed. Very little strontium is retained in the soft tissue, so that the amount of strontium-90 in the edible parts of the animal is negligible. It is of particular interest, too, that the strontium-90/calcium ratio in cow's milk is also much lower than that in the cow's feed, since this is an important barrier to the consumption of strontium-90 by man. This barrier does not operate, of course, when plant food is consumed directly by human beings. However, it appears that about three-fourths of the calcium, and hence a large fraction of the strontium-90, in the average diet in the United States is obtained from milk and milk products. The situation may be different in areas where a greater or lesser dependence is placed upon milk and milk products in the diet.

10.20 Not all of the strontium-90 that enters the body in food is deposited in the human skeleton. An appreciable fraction of the strontium-90 is eliminated, just as is most of the daily intake of calcium. However, there is always some fresh deposition of calcium taking place in the skeletal structure of healthy individuals, so that strontium-90 is incorporated at the same time. The rate of deposition of both calcium and strontium-90 is, of course, greater in growing children than in adults.

10.21 In addition to the fact that the human metabolism discriminates against strontium, it will be noted that, in each link in the food chain, the amount of strontium-90 retained is somewhat less than in the previous link. Thus, a series of safeguards reduce deposition of strontium in human bone. A comparison, made in 1955, of the strontium-90/calcium ratio in the bones of children compared with the ratio in the soil gave a discrimination factor of about one-twelfth, that is to say, the strontium-90/calcium ratio in children's bones was found to be one-twelfth of the ratio in soil. Later measurements indicate that the proportion of strontium-90 getting into the bones may be considerably smaller than this.

Strontium-90 Activity Levels

10.22 As there has been no experience with appreciable quantities of strontium-90 in the human body, the relationship between the probability of serious biological effect and the body burden of this isotope is not known with certainty, since it must be estimated indirectly. Such tentative estimates have been based on a comparison of the effects of strontium-90 with radium on experimental animals, and on the known effects of radium on human beings. From these comparisons it has been estimated that a body content of 10 microcuries (1 microcurie is a one-millionth part of a curie, as defined in § 9.118) of strontium-90 in a large proportion of the population would produce a noticeable increase in the occurrence of bone cancer. On this basis, the National Committee on Radiation Protection and the International Commission on Radiological Protection have suggested that, for individuals exposed to strontium-90 due to their occupation, the maximum permissible (or safe) amount of strontium-90 in the body should be 1 microcurie. Since the average amount of calcium in the skeleton of an adult human is about 1 kilogram, this corresponds to a concentration in the skeleton of 1 microcurie of strontium-90 per kilogram of calcium, i. e., one-tenth of the concentration which might be expected, on the average, to produce an observable effect above normal. For the population as a whole, the limit generally considered to be acceptable is 0.1 microcurie of strontium-90 per kilogram of calcium. This limit is in accord with the recommendations made in 1956 by the U. S. National Academy of Sciences.

10.23 As a result of nuclear test explosions in various countries during the past several years, there has been a small but steady gain in the strontium-90 content of the soil, plants, and the bones of animals. This increase is world-wide and is not restricted to areas in the vicinity of the test sites, although it is naturally somewhat higher in these regions because of the more localized fallout.[2] As the fine particles descend from the stratosphere, over a period of years, the gradual increase in the amount of strontium-90 may be expected to continue for some time, although there will be a certain amount of compensation due to natural decay.

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[2] As stated in § 10.10, in the case of a surface or near-surface burst, an appreciable proportion of the strontium-90 formed will be found in the local fallout. It is then to be expected that areas near the explosion will be more highly contaminated in this isotope than are more distant regions, to an extent dependent upon such factors as the height (or depth) of burst, the total and fission yields of the explosion, and the prevailing atmospheric conditions. There is evidence that in the local fallout the strontium-90 constitutes a smaller percentage of the total fission products than it does farther away. This may be accounted for by the fact that the strontium-90 is not a direct fission product and so it is not formed at the instant of the explosion. It is produced gradually over a period of some minutes, as a result of two stages of radioactive decay starting with the gas krypton-90 which is formed in the fission process (see § 11.121).

10.24 The quantities of strontium-90 that have accumulated so far in human beings are well below limits regarded as acceptable for the general population, and much less than those which might be expected to cause an observable increase in the frequency of bone tumors. Because the skeletons of very young children have developed under current fallout conditions, their content of strontium-90 provides the best indication of the maximum levels which might be expected to exist. As of January 1957, this was somewhat below one-thousandth (0.001) microcurie of strontium-90 per kilogram of calcium. Although there will be some increase toward a higher level, it is fairly certain, that if nuclear tests are carried out in the future at about the same rate as in the past, the long-term biological effects of strontium-90 will not be detectable. In the event that nuclear weapons with high fission yields were used extensively in warfare, calculations, based on somewhat uncertain premises, suggest that bomb debris from many thousands of megatons of fission would have to be added to the stratosphere before the worldwide fallout from these weapons would lead to a concentration of 1 microcurie of strontium-90 per kilogram of calcium in human beings.[3]

[3] A very thorough and comprehensive investigation of the strontium-90 hazard and of methods for combating it is being sponsored by the U. S. Atomic Energy Commission (Project Sunshine); for summary reports and references, see W. F. Libby, *Science, 123,* 657 (1956); *Proceedings of the National Academy of Sciences, 42,* 365, 945, (1956); J. L. Kulp, W. R. Eckelmann, and A. R. Schulert, *Science, 125,* 219 (1957).

Beta particles from sources on or near the body can also cause skin burns

General Radiation Effects

11.51 A skin exposure dose of 700 roentgens of X-rays will cause a certain degree of erythema (reddening) if administered locally to a small area over a period of 1 hour. However, to produce the same apparent effect with two shorter treatments separated by an interval of 24 hours, each dose must be about 535 roentgens, so that a total of 1,070 roentgens is required. If the exposure is spread over a period of 1 month, the total dose may approach 2,000 roentgens in order to cause the same degree of erythema. The explanation of these results is that in the skin new cells are continually being produced at a rapid rate in order to take care of normal wear and tear. Hence, the majority of cells damaged (or killed) by radiation are replaced by new cells and there is a certain amount of natural recovery between successive doses.

11.52 Although in most cases the rate of formation of new cells is not as great as it is in the skin, the ability to recover, to some extent, from the effects of radiation appears to be possessed by many body tissues. The rate of replacement of mature cells of blood-forming tissues and of the lining of the gastro-intestinal tract, as well as of sperm cells, is also very great.

11.53 It was seen in Chapter IX that the human body is able to withstand continual exposure to small doses of radiation from natural sources without any obviously harmful consequences. The probable reason, as implied above, is that most of the cells damaged by the radiation are replaced by new ones. But if the rate of delivery of the radiation is high or the total dose received in a relatively short time is large, recovery cannot keep pace with the damage, and injury results.

11.54 Whether the injury due to nuclear radiation is reparable or not, appears to depend to a large extent on the natural capability of the affected organ (or organ system) to repair itself as a result of damage of any kind. Thus, radiation injury to brain and kidney is largely irreparable, but damage to bone marrow, the gastro-intestinal tract, and skin, on the other hand, is to a great extent reparable.

11.55 It has already been indicated that the injury caused by a certain dose of radiation will depend upon the extent and part of the body that is exposed. For example, an acute exposure dose of 700 roentgens applied to a small region may result in considerable biological damage to the irradiated area, but the over-all health of the individual may be apparently unaffected. If the whole body receives the dose of 700 roentgens, however, death will probably result. One reason for this difference is that when the exposure is restricted, the unexposed regions can contribute to the recovery of the injured area. But if the whole body is exposed, many organs are affected and recovery is much more difficult.

11.56 Different portions of the body show different sensitivities to radiation, although there are undoubtedly variations of degree among individuals, as will be seen below. In general, the most radiosensitive parts include the lymphoid tissue, bone marrow, spleen, organs of reproduction, and gastro-intestinal tract. Of intermediate sensitivity are the skin, lungs, kidney, and liver, whereas muscle and full-grown bones are the least sensitive.

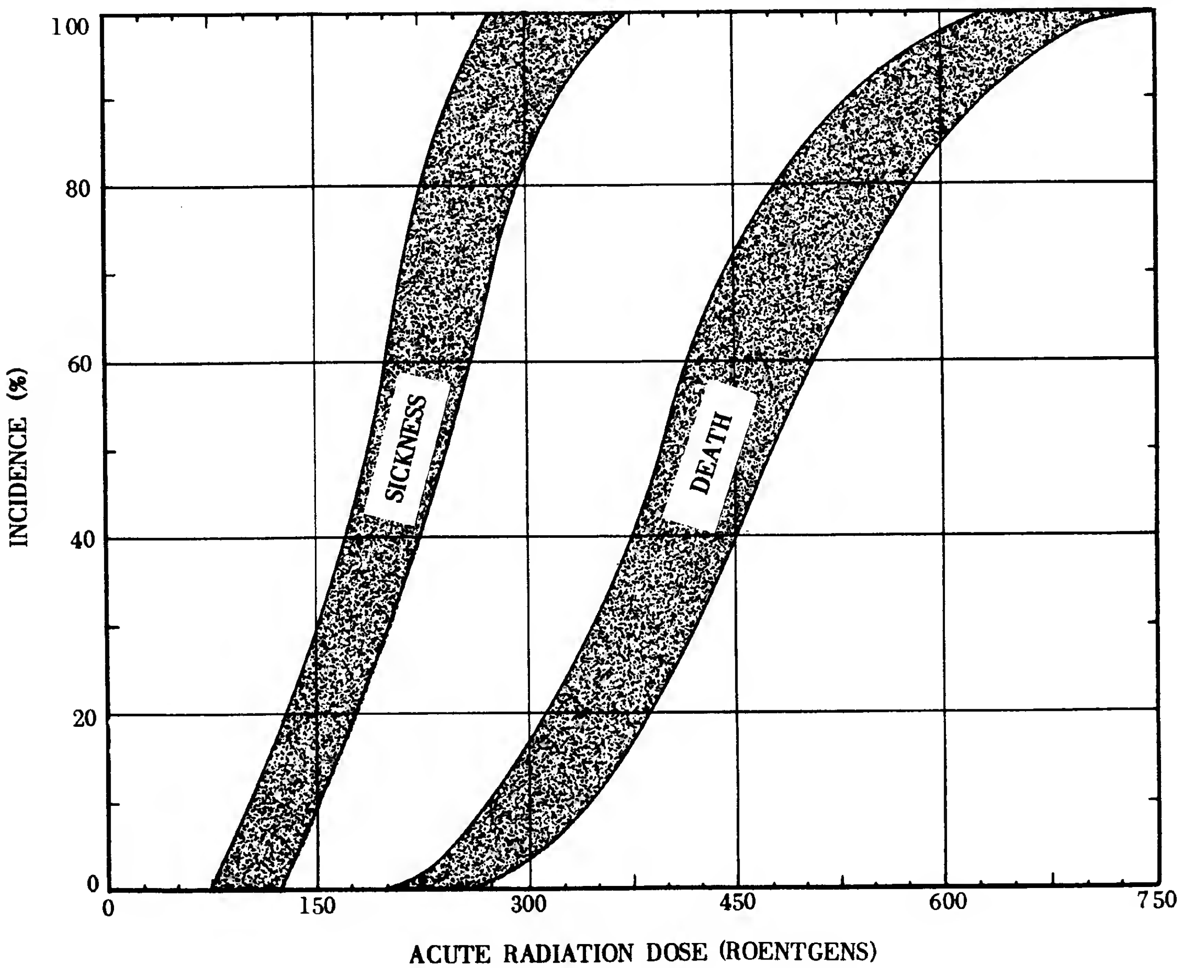

Figure 11.57. Incidence of sickness and death due to acute exposure to various doses of nuclear radiation.

11.87 Essentially all of the cases of leukemia, which could be attributed to radiation because of other symptoms, e. g., epilation, occurred among individuals who were within about 4,600 feet (0.9 mile) of ground zero. In this region, the minimum radiation dose, probably received over an extensive part of the body, must have approached the median lethal value of 450 roentgens. A survey of a large number of these patients showed that the incidence of leukemia among the survivors was, on the average, about one in 500 compared with one in 50,000 among the general (unexposed) population of Japan. **(60 years later, the long term cancer risk is still small)**

12.82 Decontamination may be either gross, i. e., rough, or detailed. Gross decontamination is the rapid, partial removal or covering of contamination on a large scale. Its purpose is to reduce the radiation dose rate as quickly as possible to a point where personnel can use a piece of equipment or remain within an area for a limited period of time, at least. Subsequently, detailed decontamination, which is a lengthy and thorough process, may be carried out. As a general rule, decontamination cannot (and need not) be complete. However, the procedure should be carried to the point where the situation no longer constitutes a significant hazard under the particular conditions of use or occupation.

12.83 The decision to undertake decontamination will depend upon the circumstances, and must involve a calculated risk. Since there is always a certain degree of danger to the operating personnel, the procedure should be deferred as long as is reasonably possible, so as to take advantage of natural radioactive decay. In some cases urgent action may be necessary, and decontamination may have to be started while the radiation level is still high. Such a situation might be met by replacement of the workers with fresh, previously unexposed, crews at short intervals.

12.84 There are a few useful general principles relating to contamination and decontamination which should be borne in mind. Because of its particulate nature, the fallout will obviously tend to collect on horizontal surfaces. Such surfaces will thus be more highly contaminated than vertical surfaces. Hence, in preliminary decontamination, at least, the latter can be ignored. Most of the fallout particles can be readily removed either by washing with a stream of water or by sweeping, preferably with a vacuum cleaner to avoid inhalation of dust.

12.85 Gross decontamination can generally be performed in one or other of these ways. For smooth, e. g., painted and metallic, surfaces, wet (washing) methods may be used, but for porous materials, e. g., fabrics, brick, concrete, and stone, dry methods are to be preferred. Broadly speaking, water washing can be employed outdoors and on the exterior of vehicles, whereas vacuum sweeping is more suitable for the interiors of buildings and vehicles. Experimental tests of decontamination procedures have shown that the major portions of contaminating material can be removed by these simple methods. Only a small part of the contamination is strongly held and requires more drastic treatment, e. g., with chemicals or abrasives.[5]

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[5] Contamination due to neutron-induced activity is difficult to remove, but such contamination is of importance only near the explosion center (see § 9.18).

Food and Water

12.97 Foods that are properly covered or wrapped or are stored in closed containers should suffer little or no contamination. This will be true for canned and bottled foods as well as for any articles in impervious, dust-proof wrappings. If the contamination is only on the outside, all that would be necessary for recovery purposes would be the careful removal, e. g., by washing, of any fallout particles that might have settled on the exterior of the container.[8] Even vegetables could be satisfactorily decontaminated by washing. If this were followed by removal of the outer layers, by peeling, the food should be perfectly safe for human consumption. Unprotected food products of an absorbent variety that have become contaminated should be disposed of by burial.

12.98 As for food crops grown in contaminated soil, there is not yet sufficient information available. Some radioactive isotopes may be taken up by the plant, but their nature and quantity will vary from one species to another and also, probably, with the soil characteristics (§ 9.99). All that can be stated at the present time is that plants grown in contaminated soil should be regarded with suspicion until their safety can be confirmed by means of radiological instruments.

12.99 Most sources of public water supplies are located at a considerable distance from urban centers that might be targets of a nuclear attack. Nevertheless, appreciable contamination might result if the watershed were in the range of heavy fallout from a surface burst. Other possibilities are fallout particles dropping into a river or reservoir or the explosion of a nuclear bomb near a reservoir. In most cases it is to be expected that, as a result of the operation of several factors, e. g., dilution by flow, natural decay, and removal ("adsorption") by soil, the water will be fit for consumption, on an emergency basis, at least, except perhaps for a limited time immediately following the nuclear explosion. In any event, where the water from a reservoir is subjected to regular treatment, including coagu-

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[8] Food could become contaminated even inside containers due to neutron-induced activity, but this is not likely to be important in locations where the packaged foodstuffs have survived the nuclear explosion intact (§ 9.25).

lation, sedimentation, and filtration, it is probable that much of the radioactive material would be removed.

12.100 Because soil has the ability to take up and retain certain elements by the process of "adsorption," underground sources of water will generally be free from contamination. For the same reason, moderately deep wells, even under contaminated ground, can be used as safe sources of drinking water, provided, as is almost invariably the case, there is no direct drainage from the surface into the well.

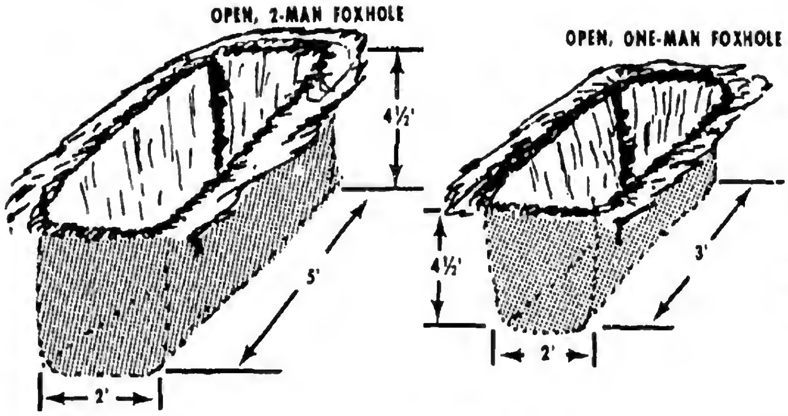
12.101 In some cities, water is taken directly from a river and merely chlorinated before being supplied for domestic purposes. The water may be unfit for consumption for several days, but, as a result of dilution and natural decay, the degree of contamination will decrease with time. It would be necessary, in cases of this kind, to subject the water to examination for radioactivity and to withhold the supply until it is reasonably safe. Assuming the contamination is due to fission products, the acceptable total beta (or gamma) activities under emergency conditions, for 10 and 30 day periods, respectively, are given in Table 12.101. Thus, if it is anticipated that the water will have to be used regularly for a period of 30 days, the maximum permissible activity is 3×10^{-2} microcuries per cubic centimeter (see § 9.125, *et seq.*). On the other hand, if it appears that the period will be shorter, water of proportionately higher activity may be consumed in an emergency.

TABLE 12.101

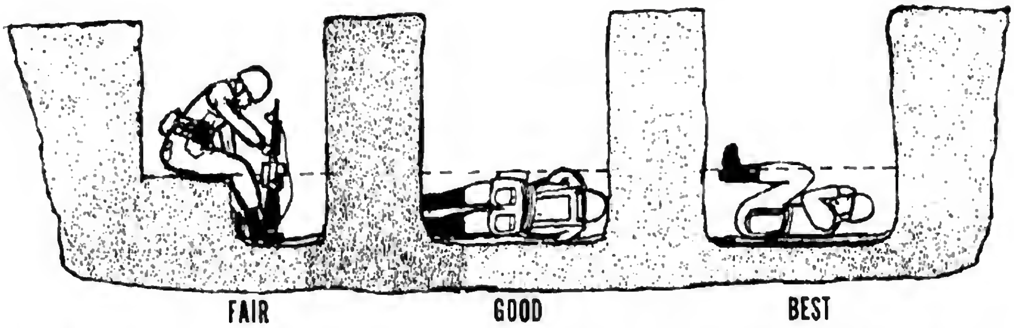
ACCEPTABLE EMERGENCY BETA (OR GAMMA) ACTIVITIES IN DRINKING WATER

	Activity	
Consumption period (days)	*Microcuries per cubic centimeter*	*Disintegrations per second per cubic centimeter*
10	9×10^{-2}	3×10^{3}
30	3×10^{-2}	1×10^{3}

12.102 The emergency limits for alpha particle emitters, such as uranium and plutonium, in water are appreciably less than those given in Table 12.101. However, it is expected that only in rare circumstances would these elements represent a contamination hazard in drinking water.



VEHICLES AS EXPEDIENT OVERHEAD COVER

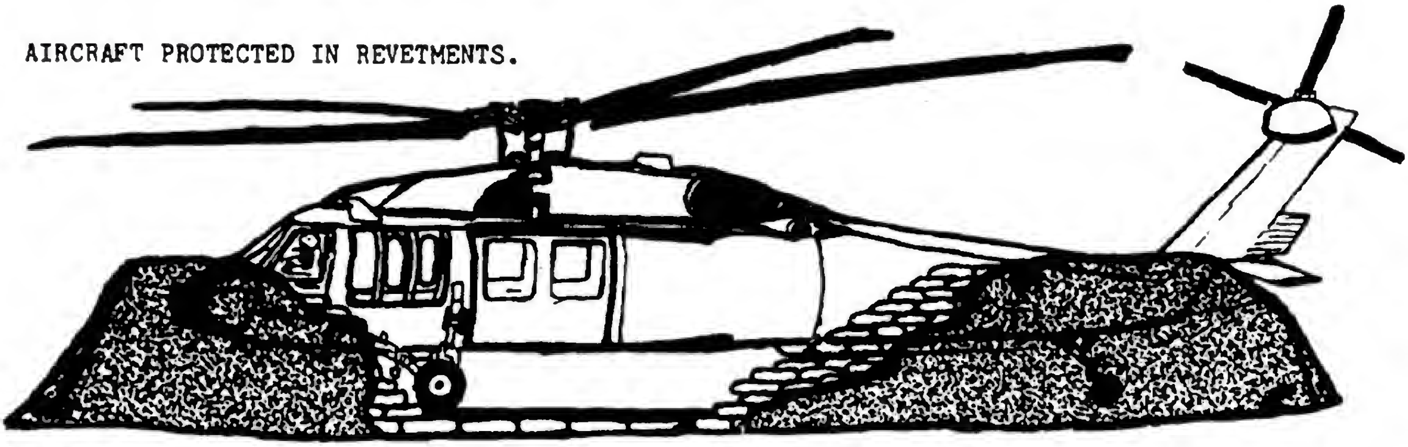


A more detailed discussion of field-expedient fortifications for protection from the effects of nuclear weapons is contained in Waterways Experiment Station Technical Report N-74-7, "Expedient Field Fortifications for Protection from the Effects of Nuclear Weapons," Sep 74.

Depth of Earth	Radiation Protection Factor	Resultant Dose (Rads)
Man in open	None	2400
Man in 4 foot deep open foxhole	8	300
with 0.5 ft of earth cover	12	200
" 1.0 ft "	24	100
" 1.5 ft "	48	50
" 2.0 ft "	96	25

Although radiation is scattered from all directions, most of it comes from direct line-of-sight to the fireball.

AIRCRAFT PROTECTED IN REVETMENTS.



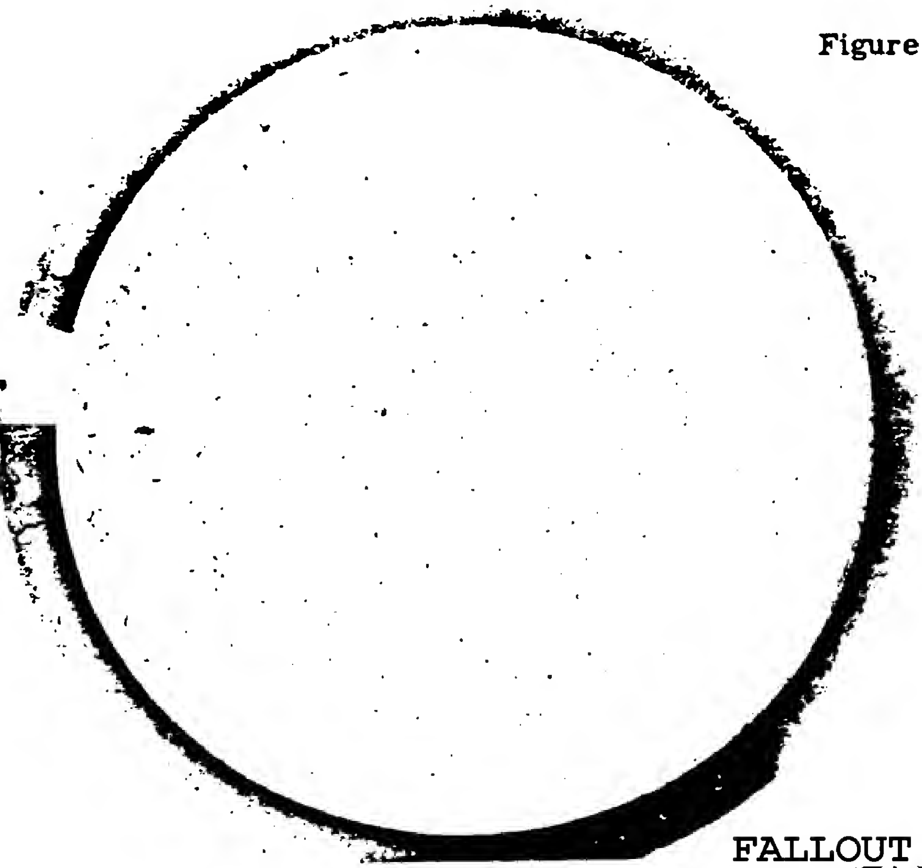
EMP Mitigation Techniques.

Mission essential tactical radios will continue to be operated before, during, and after a nuclear attack. Most tactical communications systems will be subjected to some degree of risk from either the long range EMP effects of a high altitude nuclear burst or the shorter range EMP from a low air burst.

--"If the mission permits, you should as a general rule remove exterior conductors." As shown in figure 25, EMP can couple with external metal conductors even if they are covered with insulation. Examples of potential EMP conductors include: (1) All types of radio antennas; (2) any wire or cable connections to include handset, external speaker and headset cables, power cables, computer interface connectors, rechargers, telephone lines, field wire, and extension cords; and (3) other metal conductors such as pipes, ducts, and fences. When use is not essential, such conductors should be disconnected or removed to prevent EMP-induced currents from being transmitted into the piece of equipment and damaging critical components (burnout) or upsetting the equipment by blowing fuzes, tripping circuit breakers, and garbling computer memories.

ACTUAL FALLOUT VISIBILITY FROM 3.53 MEGATON ZUNI NUCLEAR TEST, BIKINI ATOLL, 1956 (LAND SURFACE BURST) IN CIRCULAR FALLOUT COLLECTION TRAYS (INNER DIAMETER 8.2 CM), WT-1317.

Figure 4.10 Close and distant particle collections

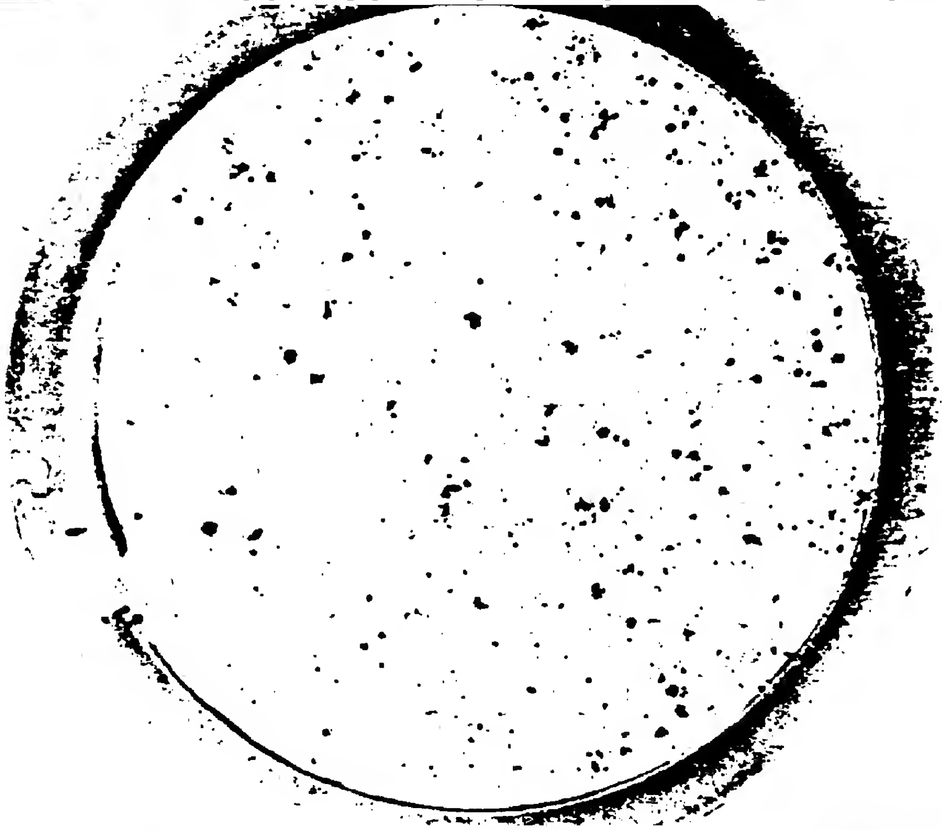


A HEAVY
COLLECTION
FAR OUT
15 MINUTE EXPOSURE

TRAY NO. 411

YAG 40, B-7
ZUNI

FALLOUT COLLECTED OVER 15 MINUTES



A HEAVY
COLLECTION
CLOSE IN
15 MINUTE EXPOSURE

TRAY NO. 1204

YFNB 13, E-57
ZUNI

TABLE 4.3

PARTICLE-SIZE VARIATION WITH TIME

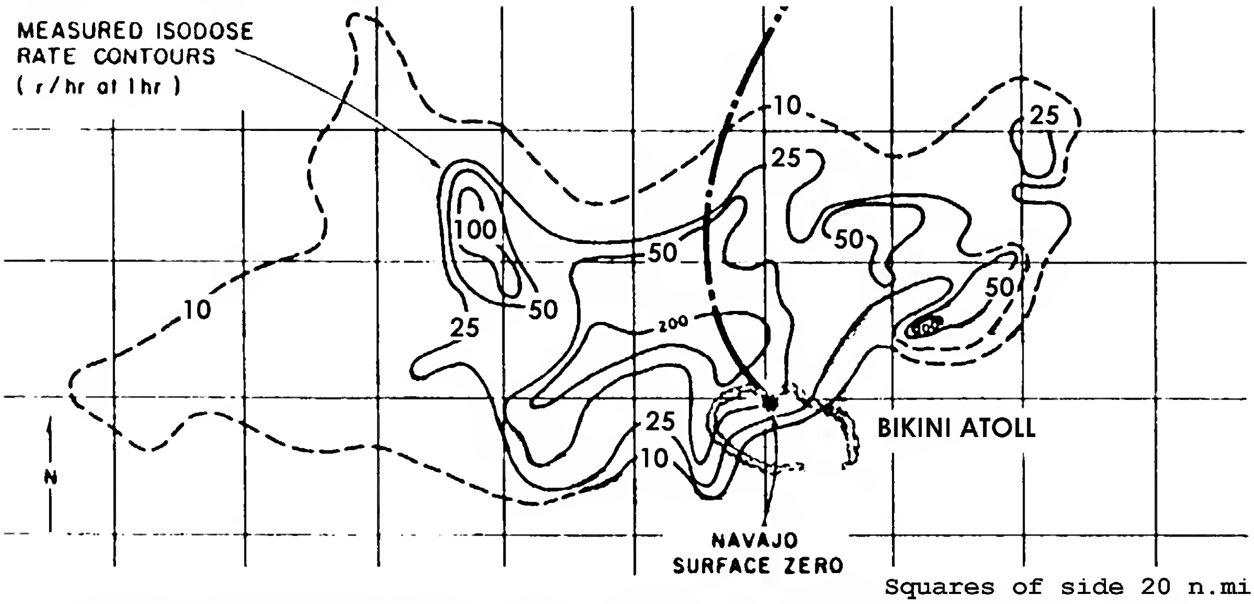
Zuni Station	Time of Arrival, hr	Maximum Particle Size (microns) at Time of Arrival	Time of Peak Activity	Time of Cessation
YFNB 13	0.33	1,400	695	545
YAG 40	3.4	325	300	245

TABLE 3.16 SURFACE DENSITY OF FALLOUT COMPONENTS IN TERMS OF ORIGINAL COMPOSITION

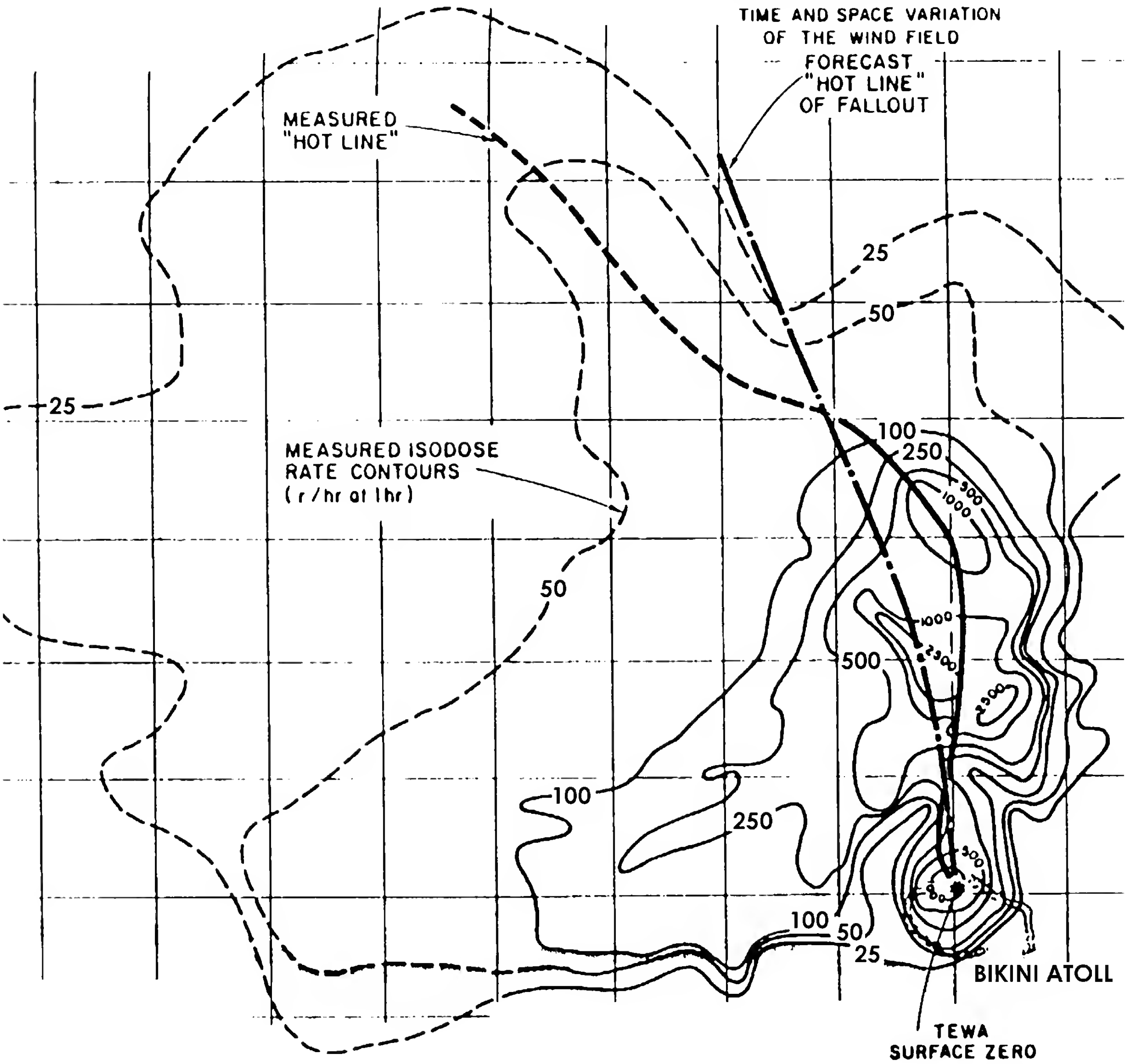
Operation Redwing, Bikini Atoll, 1956. Weapon test report WT-1317

Shot	Collector	Weight, mg/ft²		
		Coral	Sea Water	Total
Flathead	YAG 40-B-19 FL	14.0 ± 1.0	195.2 ± 16.2	209.2 ± 16.2
365 kt	LST 611-D-51 FL	0.0 ± 1.0	89.2 ± 16.2	89.2 ± 16.2
water	YFNB 13-E-56 FL	1.6 ± 1.0	6,155.0 ± 31.3	6,156.7 ± 31.3
surface	How F-67 FL	0.0 ± 2.57	32.6 ± 17:7	32.6 ± 17.9
burst	YFNB 29-H-81 FL	5.4 ± 1.0	564.2 ± 31.3	569.5 ± 31.3
Navajo	YAG 40-B-19 NA	4.3 ± 1.0	646.8 ± 31.3	651.1 ± 31.3
4.5 Mt	YAG 39-C-36 NA	3.2 ± 1.0	1,415.4 ± 31.3	1,418.6 ± 31.3
water	LST 611-D-51 NA	13.0 ± 1.0	1,299.5 ± 31.3	1,312.5 ± 31.3
surface	YFNB 13-E-54 NA	51.6 ± 1.0	5,129.8 ± 31.3	5,181.5 ± 31.3
burst	How F-67 NA	12.0 ± 2.6	561.3 ± 35.4	573.3 ± 35.4
	YFNB 29-H-81 NA	24.0 ± 1.0	0.0 ± 31.3	24.0 ± 31.3
Zuni	YAG 40-B-17 ZU	1,810.1 ± 1.0	116.8 ± 16.2	1,927.0 ± 16.2
3.53 Mt	YAG 40-B-19 ZU	522.6 ± 1.0	166.1 ± 31.3	688.7 ± 31.3
coral	YAG 39-C-23 ZU	17.8 ± 1.0	88.6 ± 16.2	106.4 ± 16.2
surface	YAG 39-C-36 ZU	19.2 ± 1.0	55.0 ± 31.3	74.2 ± 31.3
burst	YFNB 13-E-56 ZU	1,574.8 ± 1.0	1,121.6 ± 16.2	2,696.4 ± 16.2
	YFNB 13-E-58 ZU	797.9 ± 1.0	583.9 ± 16.2	1,381.8 ± 16.2
	How F-63 ZU	989.5 ± 2.6	86.7 ± 0.3	1,076.2 ± 2.6
	How F-67 ZU	592.3 ± 2.6	221.8 ± 17.7	814.2 ± 17.9
	YFNB 29-H-79 ZU	2,912.9 ± 1.0	561.0 ± 16.2	3,473.8 ± 16.2
	YFNB 29-H-81 ZU	2,788.4 ± 1.0	1,274.2 ± 16.2	4,062.6 ± 16.2
Tewa	YAG 40-B-19 TE	661.7 ± 1.0	273.6 ± 16.2	935.3 ± 16.2
5.01 Mt	YAG 39-C-36 TE	1,726.8 ± 1.0	517.5 ± 16.2	2,244.4 ± 16.2
coral	LST 611-D-51 TE	62.9 ± 1.0	0.0 ± 31.3	62.9 ± 31.3
surface	YFNB 13-E-56 TE	54.1 ± 1.0	199.0 ± 16.2	253.2 ± 16.2
burst	How F-67 TE	15.0 ± 2.4	13.6 ± 0.2	28.6 ± 2.4
	YFNB 29-H-81 TE	4,533.1 ± 1.0	0.0 ± 31.3	4,533.1 ± 31.3

CLEAN WEAPON (4.5 MT, 5% FISSION): REDWING-NAVAJO, 1956



DIRTY WEAPON (5 MT, 87% FISSION): REDWING-TEWA, 1956



COMPARISON OF FALLOUT FROM A CLEAN (LEAD PUSHER) AND A DIRTY (U238 PUSHER) H-BOMB.
BOTH TESTS AT BIKINI ATOLL, OPERATION REDWING, 1956 (WEAPON TEST REPORT WT-1317)
NOTE THAT 1 HOUR REFERENCE DOSE RATES DO NOT EXIST AT 1 HOUR SINCE FALLOUT TAKES LONGER TO ARRIVE (DATA COLLECTED AT 48 HOURS WERE CORRECTED FOR DECAY TO 1 HOUR, MULTIPLYING THE 48 HOUR DOSE RATES BY A FACTOR OF 100 TO GIVE FAKE 1 HOUR OUTDOOR LAND LEVELS.)

WT-942 (EX)
EXTRACTED VERSION

OPERATION CASTLE

Radiological Safety

J. D. Servis

Pacific Proving Grounds
March-May 1954

Joint Task Force Seven

August 1954

NOTICE

This is an extract of WT-942, Operation CASTLE, which remains classified SECRET/RESTRICTED DATA as of this date.

BEST COPY AVAILABLE

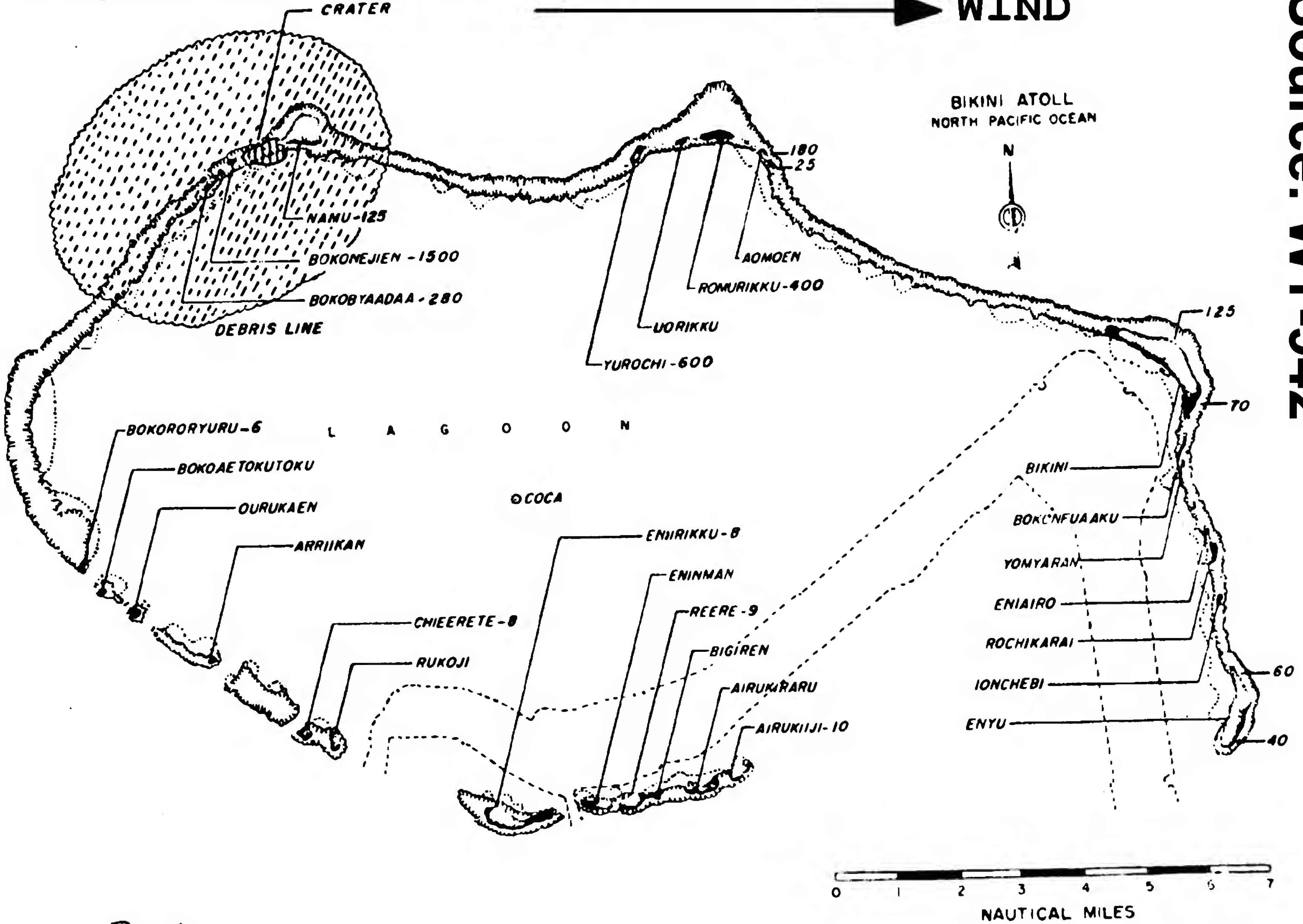
Extract version prepared for:

Director
DEFENSE NUCLEAR AGENCY
Washington, D.C. 20305

1 April 1981

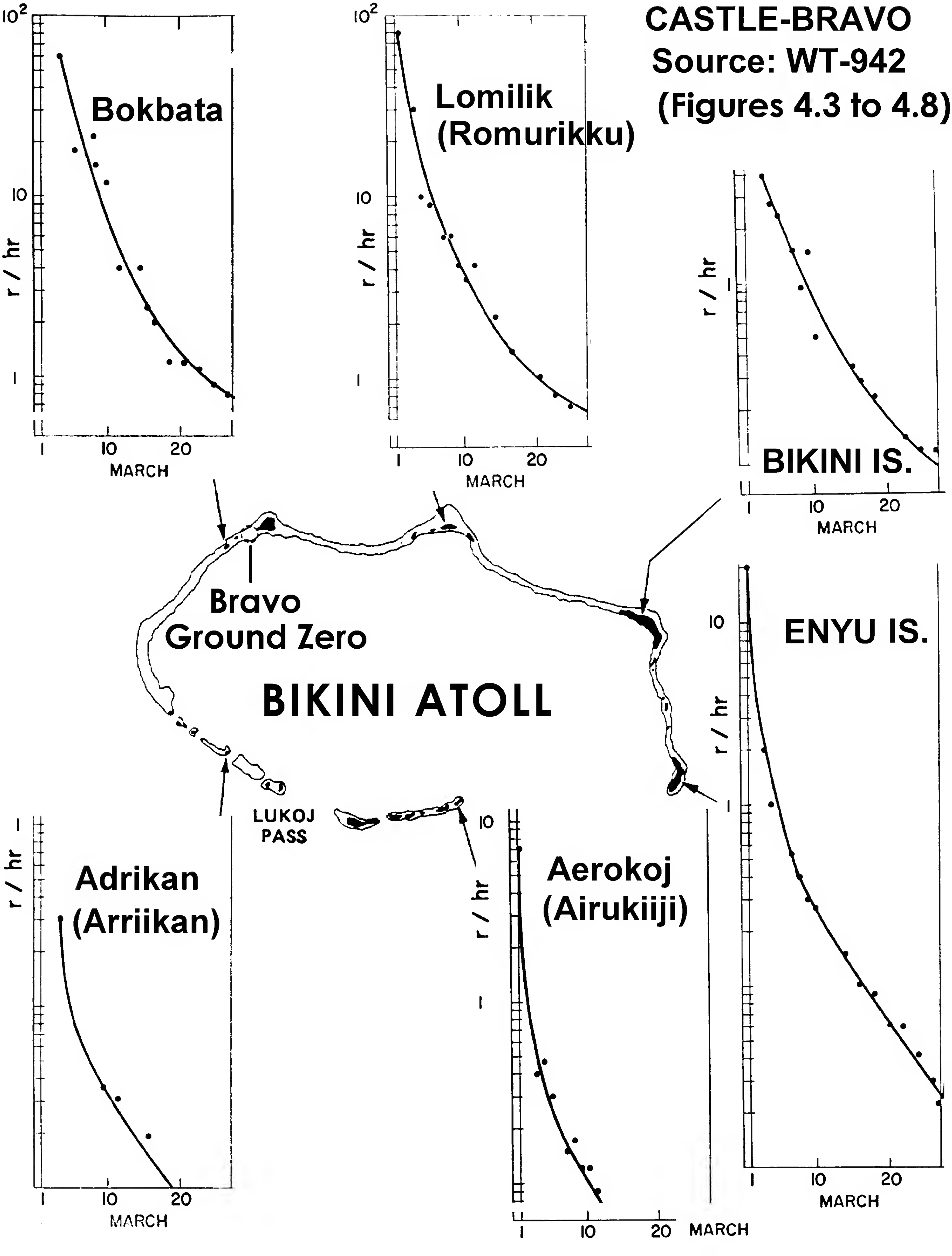
Source: WT-942

15 megatons Castle-Bravo, 1 March 1954



BRAVO

Fig. 4.1— Iradiation intensities in roentgens per hour extrapolated to H + 4 hr. Location, on reef 2950 ft; bearing, 250 deg true from southwest tip of Namu. Yield, 15 Mt Time fired, 01/0645M March 1954.



CASTLE-BRAVO
Source: WT-942
(Figures 4.3 to 4.8)
Bokbata
Lomilik
(Romurikku)
BIKINI IS.
ENYU IS.
Bravo
Ground Zero
BIKINI ATOLL
LUKOJ
PASS
Adrikan
(Arriikan)
Aerokoj
(Airukiiji)
r / hr
MARCH

DISTRIBUTION, CHARACTERISTICS, AND BIOTIC AVAILABILITY OF FALLOUT, OPERATION PLUMBBOB

WT-1488

By:

K. H. Larson, J. W. Neel, H. A. Hawthrone,
H. M. Mork, R. H. Rowland, L. Baurmash,
R. G. Lindberg, J. H. Olafson, B. W. Kowalewsky

Approved by: K. H. LARSON
Director
Program 37

Approved by: L. J. DEAL
Chief
Civil Effects Branch

Issuance Date : July 26, 1966

Laboratory of Nuclear Medicine and Radiation Biology
The University of California at Los Angeles

Observations of the remains of towers and shielding material after detonation at several ground zeros indicate that large masses of material are not vaporized. Observation of the residue of the Smoky tower indicated that a very significant portion of that tower remained including the upper 200 feet of steel. Another example similar to Shot Smoky was Shot Apple II, Teapot Series. Even though the total yield of Shot Apple II was about 32 kt, the floor of the cab and the main tower support columns remained intact. The results of the Shot Fizeau tower melt studies (Reference 3) show that about 85 percent of tower material was accounted for after the detonation and that only the upper 50 feet of tower was vaporized. No melting occurred beyond 175 feet from the top of the tower although the fireball theoretically engulfed more than 400 feet of the tower.

These observations indicate that before a realistic approach can be made in formulating reliable prediction models, information should be obtained as to how much material is actually consumed in the formation of fallout particles.

REFERENCES

3. W. K. Dolen and A. D. Thornborough; "Fizeau Tower Melt Studies as Related to Fallout Prediction"; Report No. SC-4185, April 1958; Sandia Corporation, Albuquerque, New Mexico; Classification, Secret.

A relationship between time of fallout arrival (T_a) to time of peak activity (T_P) was derived; $T_P = 1.4\ T_a$.

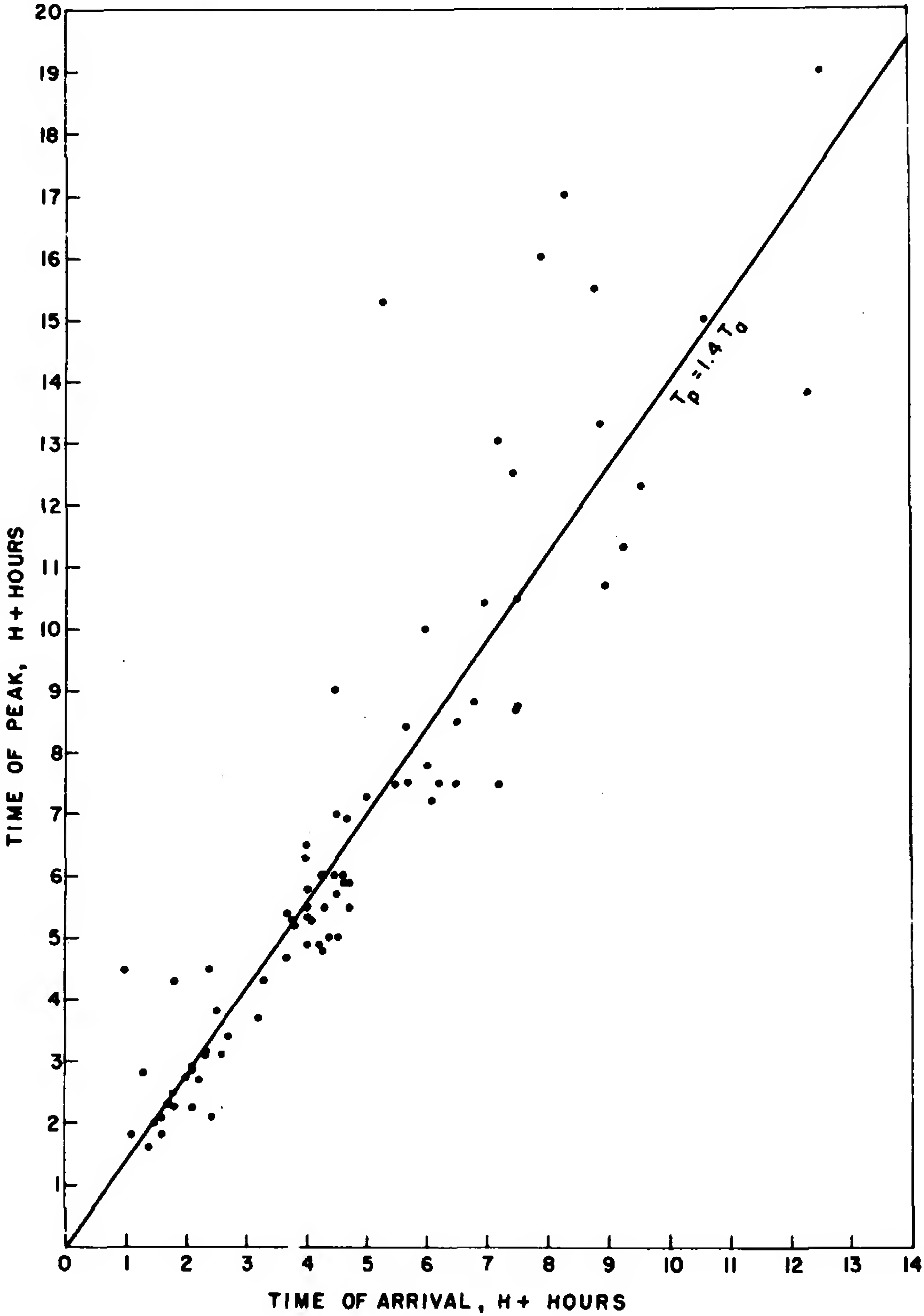


FIGURE 2.13 Relationship of Time of Peak Activity as a Function of Time-of-Arrival of Fallout or Radiation.

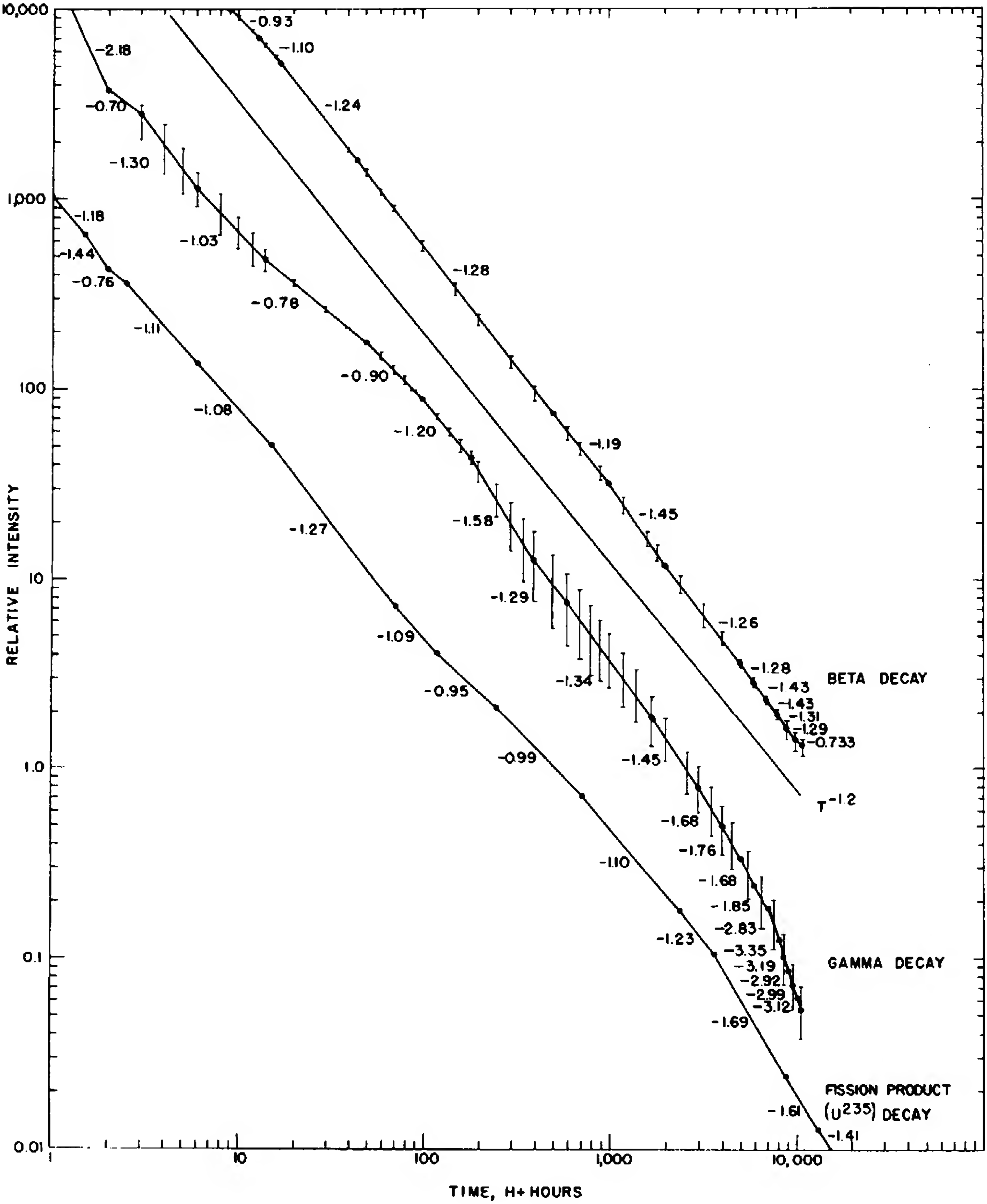


FIGURE 4.11 Plumbbob Composite Beta and Gamma Decay Curves.

TABLE 7.13 Beta Activity in Tissues of Jackrabbits and Kangaroo Rats, (Smoky Fallout Pattern)

Time of Collection, D + days	Dose Rate, mr/hr	No. in Sample	Average nc/gm of Tissue at Time of Collection				
			Skin	Lung	Thyroid	Muscle	Bone
Jackrabbits (Lepus)							
Station VII (136 miles from GZ)							
3	2.91	4	39.3	0.451	497	0.330	0.952
5	1.79	5	35.1	0.252	138	0.249	1.14
9	1.10	4	10.8	0.190	89.5	0.129	1.50
13	0.70	1	12.2	nil	52.7	0.035	0.755
20	0.48	5	3.57	nil	18.8	0.044	0.671

TABLE 7.12 I^{131} and I^{133} in Thyroid of Jackrabbits, (Shasta Fallout Pattern)

See Table 7.1 for station radioactivity levels. Measurements made by single channel spectrometer using a 2 inch NaI crystal.

Sta. No.	Miles from GZ	Time of Collection H + hr	No. of Animals Sampled	Pct at H + 72 hrs			Ratio I^{133}/I^{131}	
				I^{131}	I^{133}	Activity Accounted for	Observed at H + 72 hrs	At Time of Collection
21	31	17	1	33	51	84	1.6	7.0
26	44	18	3	23	63	86	2.7	12
19	17	42	3	20	67	87	3.3	8.0
26	14	42	3	17	65	82	3.8	8.7
31	76	41	3	17	66	83	3.9	9.1

Samples of the soil profile were collected in Station VI area 3 days, 12 months, and 24 months after Shot Smoky. The analysis of these samples (Table 7.24), indicates that the Sr^{90} is primarily restricted to the surface inch with relatively small amounts in the second inch. This analysis is in agreement with similar studies of beta radioactivity and plutonium movements downward into soil over considerably longer periods of time in New Mexico soils contaminated by the Trinity Shot of 1945 (See Chapter 1).

Hence 2nd inch had ~20% of top inch conc.

TABLE 7.24 Effect of Time on Distribution of Sr^{90} Levels in Soil Profile, Station VI

	Depth, inches	Soil Sr^{90} Level of Samples mc/mi^2 at time of analysis (1959)		
		D + 3 days	D + 12 months	D + 24 months
Stake 1	0 - 1	104	89.5	128
	1 - 2	19.2	13.7	9.20
	2 - 3	Bkg[a]	Bkg	--
	3 - 4	Bkg	Bkg	--
Stake 13	0 - 1	112	154	106
	1 - 2	22.9	9.76	14.2
	2 - 3	15.9[b]	Bkg	--
	3 - 4	2.79[b]	Bkg	--
Stake 16	0 - 1	130	169	178
	1 - 2	19.5	29.8	3.07
	2 - 3	Bkg	5.58[b]	--
	3 - 4	Bkg	Bkg	--

[a] Bkg: Soil background.

[b] Probably sample contamination during collection.

"A Tragedy of Misunderstanding: there was no major radiation disaster at Fukushima"

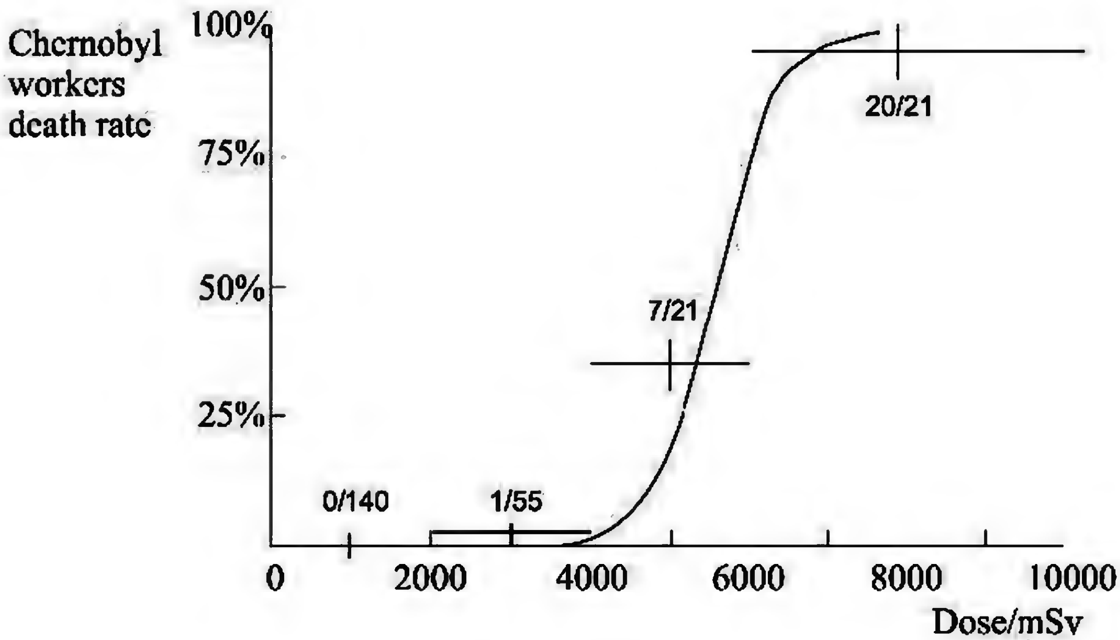
An invited talk at the Annual Meeting of the American Nuclear Society,
Chicago, 25 June 2012
by Wade Allison, Emeritus Professor of Physics at the University of Oxford, UK

Summary

Low or moderate radiation doses are benign but the public health effects of fear and panic, caused by ignorance and over-cautious international "safety" standards, are dangerous, both to individuals and to the society and economy at large. A disaster of fear, not radiation, occurred at Fukushima as a result of the damage to the nuclear plant.

When the earthquake struck there were 500,000 people in the region subsequently inundated by the tsunami and within 26 to 45 minutes, all except 18,880 had managed to escape, a truly remarkable achievement. The training and understanding of the Japanese people that was evident for the tsunami was absent for the release of radiation and radioactivity. Faced by an unknown threat, nobody knew what action to take, and few in authority knew either, so that rumour and panic, extending to the highest levels, lead to serious social harm, widespread voluntary evacuation, failed businesses and losses of confidence in society and nuclear power. This failure of society to cope with an accident, for which no loss of life should be expected, is strange. Fear of powerful energy is a protective animal reaction, but man has survived dangers through study, understanding and mutual organisation -- although not in the case of radiation and radioactivity. Why not?

Cell death from an acute dose. Figure 4 refers to the 237 initial firefighters at Chernobyl who received high doses in a short period. Within a few weeks 28 were dead from ARS. Further deaths since then were probably not related to radiation. The crosses on the figure follow a typical stabilisation curve with a threshold of 2000 to 4000 mSv. The curve shows similar data for laboratory rats.

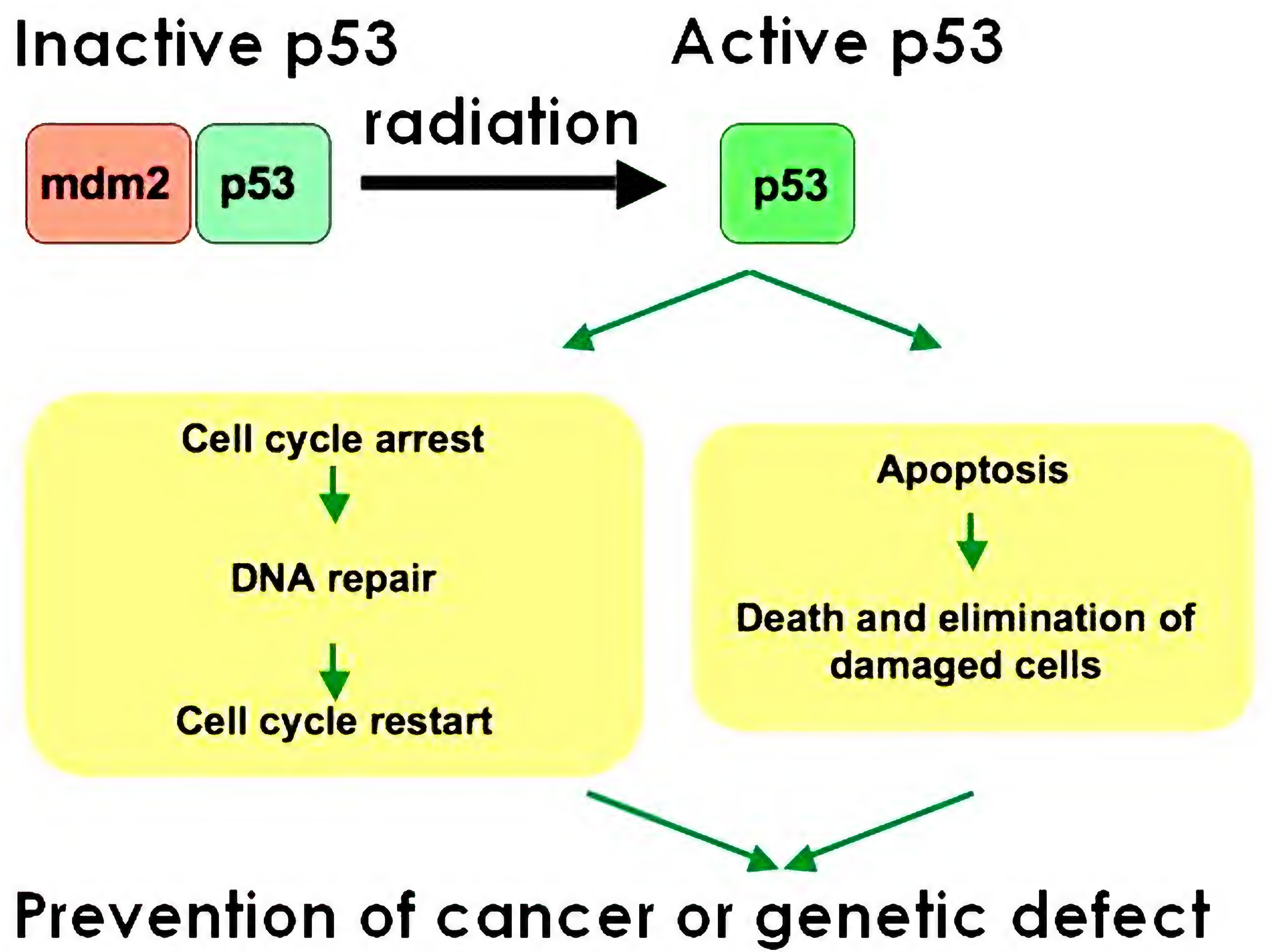


Dose range milli-sievert	Number in 1950	Cancer deaths (excl. leukaemia)		Leukaemia deaths	
		total rate	rate from radiation	total rate	rate from radiation
Less than 100	68467	11.2%	0.09%	0.2%	0.01%
100 to 200	5949	12.3%	0.7%	0.2%	-0.01%
200 to 1000	9806	13.2%	1.9%	0.6%	0.3%
More than 1000	1829	24.1%	8.1%	3.5%	2.4%
All	**86611**	**11.7%**	**0.6%**	**0.3%**	**0.1%**

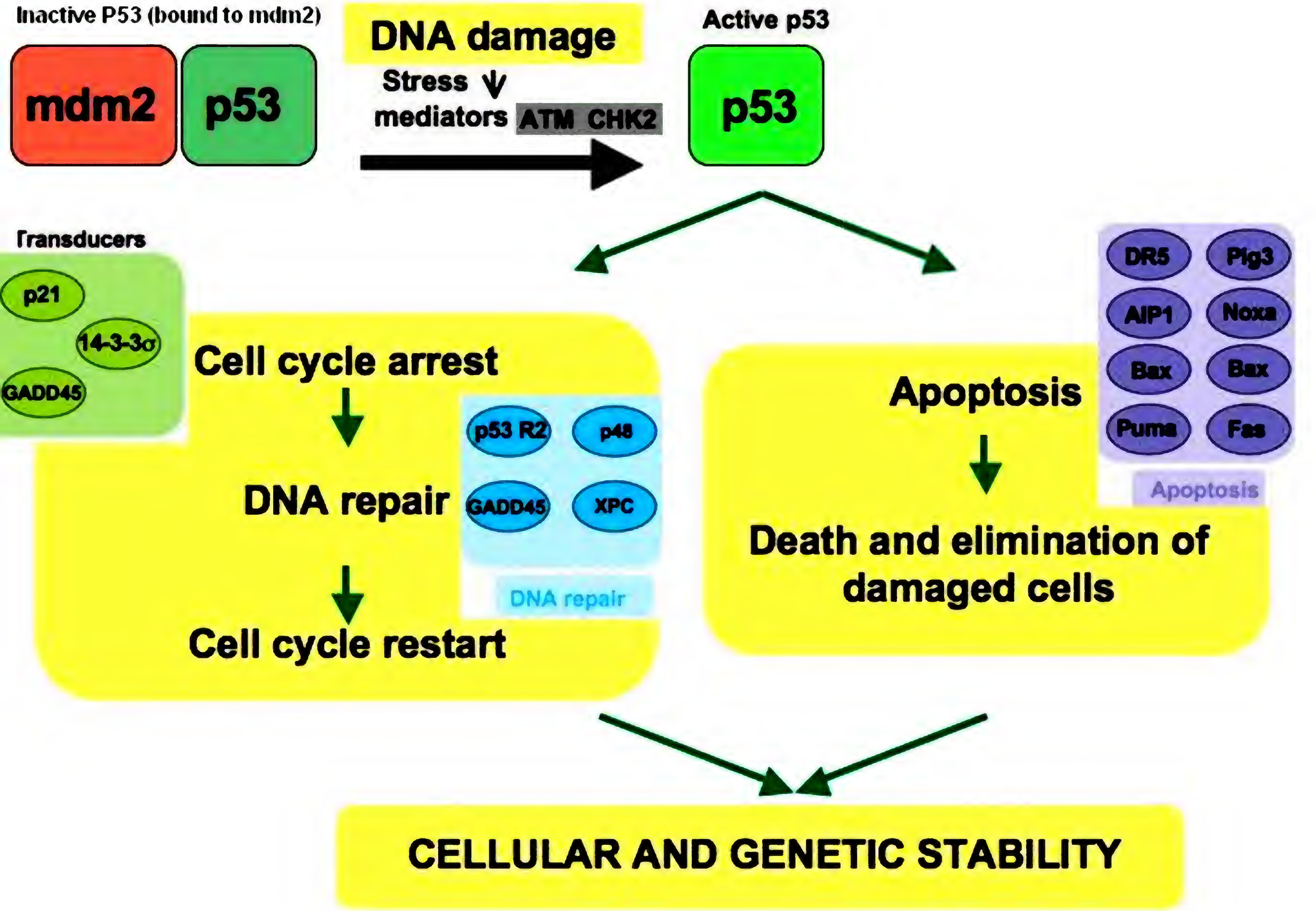
Cancer deaths among 86611 Hiroshima and Nagasaki survivors, 1950-2000
The total radiation-related deaths from solid cancer and leukaemia were 480 and 93, respectively.

http://www.bioone.org/doi/abs/10.1667/RR3232

Preston, D. L., Pierce, D. A., Shimizu, Y., Cullings, H. M., Fujita, S., Funamoto, S. and Kodama, K., "Effect of Recent Changes in Atomic Bomb Survivor Dosimetry on Cancer Mortality Risk Estimates," Radiat. Res. v162, pp377–389 (2004).



Inactive p53
Active p53
radiation
mdm2
p53
p53
Cell cycle arrest
DNA repair
Cell cycle restart
Apoptosis
Death and elimination of damaged cells
Prevention of cancer or genetic defect



Inactive P53 (bound to mdm2)
mdm2
p53
DNA damage
Stress
mediators
ATM CHK2
Active p53
p53
Transducers
p21
14-3-3σ
GADD45
Cell cycle arrest
DNA repair
Cell cycle restart
p53 R2
p48
GADD45
XPC
DNA repair
Apoptosis
Death and elimination of damaged cells
DR5
Pig3
AIP1
Noxa
Bax
Bax
Puma
Fas
Apoptosis
CELLULAR AND GENETIC STABILITY

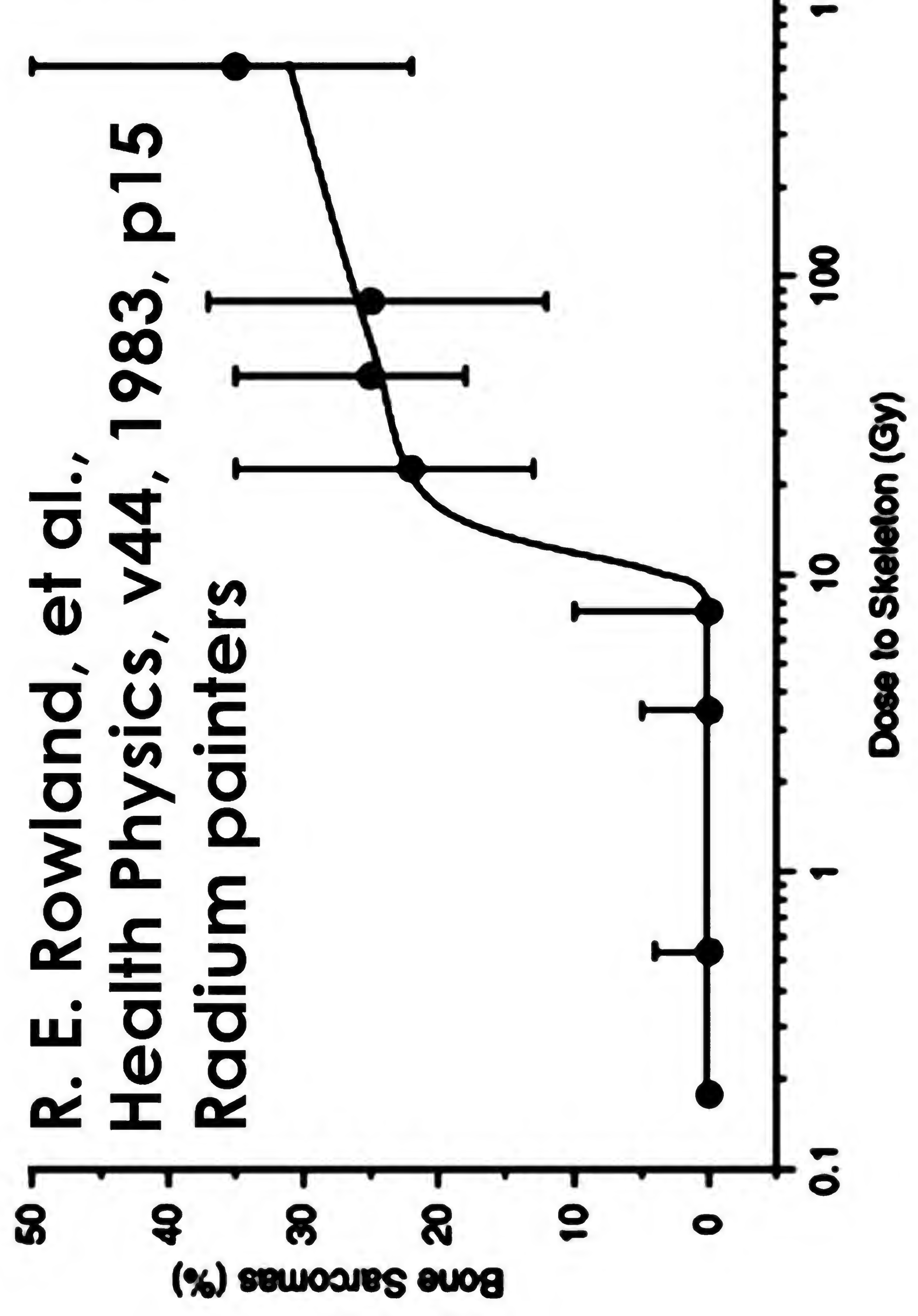
Radiation genetics surprise

IT has long been one of the basic axioms of radiation genetics that the genetic mutation rate due to radiation is independent of the radiation intensity, or dose-rate, and depends only on the total integrated dose.

Recent experiments reported by Russell *et al.* (*Science*, 128, 1546) have shown that most of the difference in the observed mutation rates is indeed due to variation in the radiation intensity.

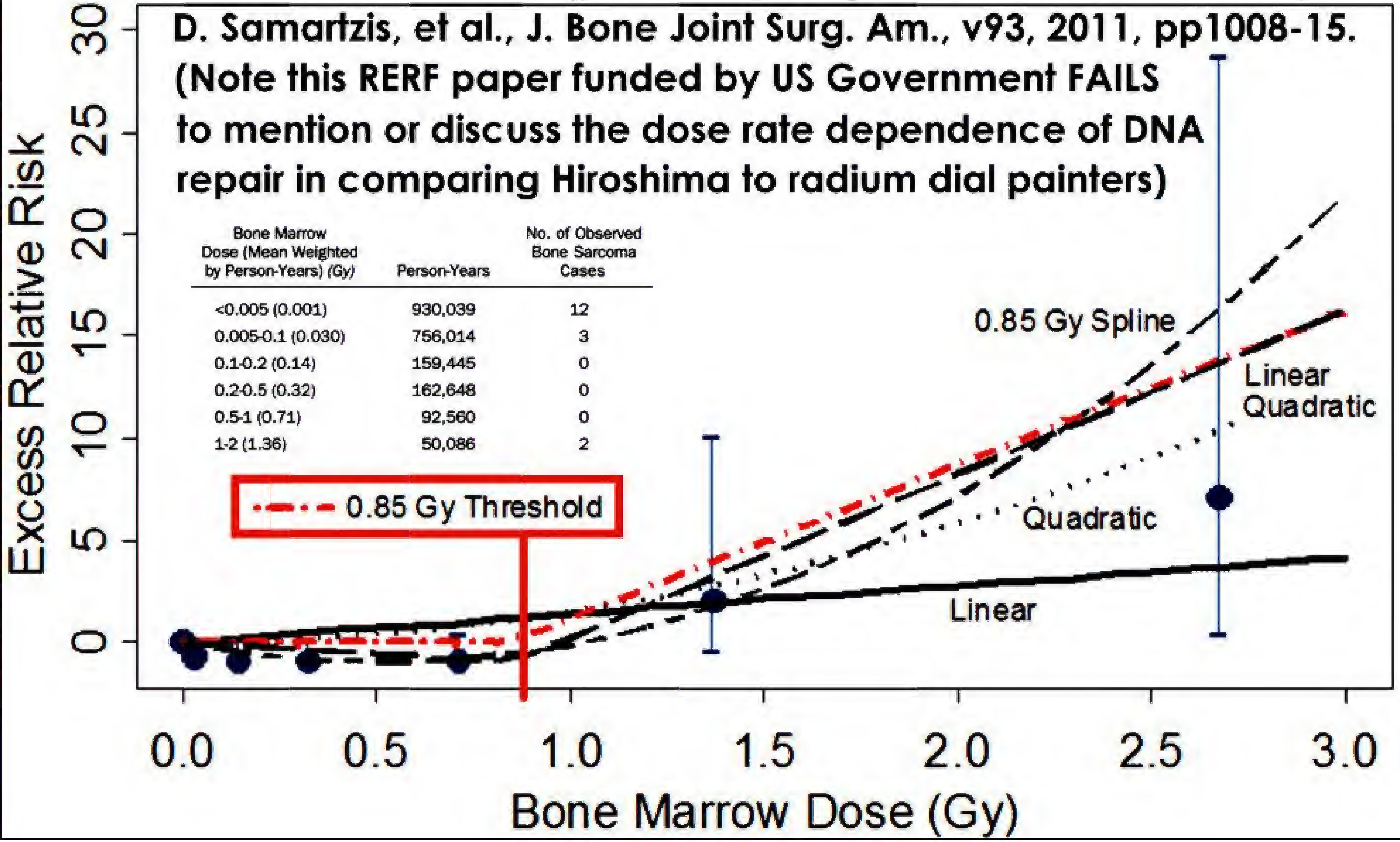
If the dose rate is significant for humans, then the genetic effect of the natural background of radiation will be much less important than that due to medical X-rays.

LOW DOSE RATE: 10 mR/h



Threshold dose and hormesis evidence for bone cancer in Hiroshima and Nagasaki (very HIGH DOSE RATE)

D. Samartzis, et al., J. Bone Joint Surg. Am., v93, 2011, pp1008-15.
(Note this RERF paper funded by US Government FAILS to mention or discuss the dose rate dependence of DNA repair in comparing Hiroshima to radium dial painters)



Bone Marrow Dose (Mean Weighted by Person-Years) (Gy)	Person-Years	No. of Observed Bone Sarcoma Cases
<0.005 (0.001)	930,039	12
0.005-0.1 (0.030)	756,014	3
0.1-0.2 (0.14)	159,445	0
0.2-0.5 (0.32)	162,648	0
0.5-1 (0.71)	92,560	0
1-2 (1.36)	50,086	2

ANL/ER-3
UC-408

Radium in Humans

A Review of U.S. Studies

by
R.E. Rowland
Environmental Research Division

Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

September 1994

Work supported by the United States Department of Energy,
Office of Energy Research, Office of Health and Environmental Research,
and Assistant Secretary for Environment, Safety, and Health,
Office of Epidemiology and Health Surveillance

The concept that radiation should have its own exposure standards grew from early radiobiological effects on humans working with the new radiation energy sources. The first official exposure standard for a radionuclide in the body was established for ^{226}Ra at a level of 0.1 μCi, by a task group assembled by the U.S. National Bureau of Standards in 1941. On the basis of the average radiation dose to the skeleton from deposited radium, a "practical threshold" dose of 10 Gy was established many decades ago by the pioneer of the work contained in this book, Dr. Robley Evans, then at the Massachusetts Institute of Technology. It was Evans who, through appearances before the Atomic Energy Commission and congressional committees, spearheaded the establishment of the Center for Human Radiobiology at Argonne National Laboratory in 1968.

Robert G. Thomas
Program Manager
Environmental Research Division

NLE MR Case No. 87-232

Document No. 9

OFFICE OF THE DIRECTOR

UNCLASSIFIED ~~CONFIDENTIAL~~

Mr. Coyne

RADIATION FALL-OUT" CONTROVERSY

2245

UNITED STATES DEPARTMENT OF JUSTICE

FEDERAL BUREAU OF INVESTIGATION

WASHINGTON 25, D. C.

June 19, 1957

PERSONAL AND ~~CONFIDENTIAL~~
VIA LIAISON

Honorable Robert Cutler
Special Assistant to the President
Executive Office Building
Washington, D. C.

DECLASSIFIED BY 275 WEW/mdm
ON 1/19/88 NLE 87-232

Dear General Cutler:

I thought you would be interested in the results of an analysis of the controversy being waged at the present time concerning the hazards of radiation effects from nuclear bomb tests, and I am enclosing a copy of this analysis for your information. Your attention is invited to the brief Introduction which appears at the beginning of the enclosure. U

This analysis reveals some of the efforts being made by communists on an international level and also by the Communist Party, USA, to exploit the present "fall-out" controversy. An outstanding feature of this controversy concerns the numerous scientists with subversive affiliations who have become associated with it. Dr. Linus Pauling, Harlow Shapley, and Edward U. Condon, familiar names in the field of science frequently associated with communist front activities in the past, are among those creating fear, misunderstanding, and confusion in the minds of the public on this issue. U

Sincerely yours,

J. Edgar Hoover

Enclosure

UNCLASSIFIED ~~CONFIDENTIAL~~

DECLASSIFIED
Authority MR 87-232 #9
By JWO NLE Date 1/29/88

UNCLASSIFIED
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COMMUNIST EXPLOITATION OF RADIATION "FALL-OUT" CONTROVERSY

June 12, 1957

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I. INTRODUCTION

Communists throughout the world are exploiting the present public controversy concerning the hazards of radiation "fallout" from nuclear bomb tests. Since 1946, basic Soviet strategy has been directed at impeding and deterring the development of nuclear weapons in this country. The present efforts of communists to exploit the "fall-out" issue are in accordance with this basic strategy.

Much of the communist agitation on the "fall-out" issue stems from a communist front organization. In 1956, the World Federation of Scientific Workers (WFSW), an "international communist front," prepared and published a 40-page booklet entitled Unmeasured Hazards, which specifically discussed the harmful effects of radiation "fallout." The booklet was published in English, French, Russian, Chinese, German, and Japanese. It was distributed in the United States by the American Association of Scientific Workers (AASW), which maintains fraternal ties with the WFSW. It should also be noted that Dr. Linus Pauling, a focal point in the present "fall-out" controversy, has been one of the vice presidents of the AASW for several years.

The Communist Party, USA, is also actively exploiting the issue. On May 19, 1957, for instance, The Worker, weekend edition of the east coast communist newspaper, the Daily Worker, featured a special four-page supplement which emphasized the danger of excess radioactivity. Over 40,000 copies of this supplement have already been ordered by Party districts for distribution throughout the country. In addition, on May 27, 1957, Eugene Dennis, secretary of the Party's national affairs department, instructed all Party members to attempt to organize a nationwide campaign in protest over the continued testing of nuclear weapons. All Party districts were instructed to advise the Party's national headquarters of any action by municipal, county, or state bodies calling for a ban on nuclear weapons; any protests by local noncommunist organizations over the continued tests; any surveys to determine the presence of excess radioactive material in water supplies or dairy products; and any unfavorable editorial comment on statements by prominent individuals against the further testing of nuclear weapons. Dennis explained this information was necessary so the Daily Worker could afford this issue "major attention and emphasis."

On an individual basis, a number of persons with subversive affiliations have been featured prominently in this "fall-out" controversy in both the communist and noncommunist press.

CONFIDENTIAL
UNCLASSIFIED

Survival of Food Crops and Livestock in the Event of Nuclear War

Proceedings of a symposium held at
Brookhaven National Laboratory
Upton, Long Island, New York
September 15–18, 1970

Sponsored by
Office of Civil Defense
U. S. Atomic Energy Commission
U. S. Department of Agriculture

Editors

David W. Bensen
Office of Civil Defense
Arnold H. Sparrow
Brookhaven National Laboratory

December 1971

U. S. ATOMIC ENERGY COMMISSION Office of Information Services

THE SIGNIFICANCE OF LONG-LIVED NUCLIDES AFTER A NUCLEAR WAR

R. SCOTT RUSSELL, B. O. BARTLETT, and R. S. BRUCE
Agricultural Research Council, Letcombe Laboratory, Wantage, Berkshire, England

ABSTRACT

The radiation doses from the long-lived nuclides ^{90}Sr and ^{137}Cs, to which the surviving population might be exposed after a nuclear war, are considered using a new evaluation of the transfer of ^{90}Sr into food chains.

As an example, it is estimated that, in an area where the initial deposit of near-in fallout delivered 100 R/hr at 1 hr and there was subsequent worldwide fallout from 5000 Mt of fission, the dose commitment would be about 2 rads to the bone marrow of the population and 1 rad to the whole body. Worldwide fallout would be responsible for the major part of these doses.

It is now widely recognized that long-lived fission products would make a negligible contribution to the radiation exposure of the population in heavily contaminated areas shortly after a nuclear attack. The external radiation dose would usually be dominant, and, if simple precautions were taken to avoid the superficial contamination of foodstuffs, the entry of ^{131}I into milk would cause the only important problem of dietary contamination. Thus, for example, infants probably would not receive doses of more than 0.1 rad to bone marrow from ^{90}Sr nor more than 0.01 rad from ^{137}Cs in the weeks after a nuclear attack if they were fed continuously with milk produced in an area where the external dose rate at 1 hr after detonation had been 100 R/hr. Doses to the thyroid from ^{131}I might, however, exceed 200 rads.

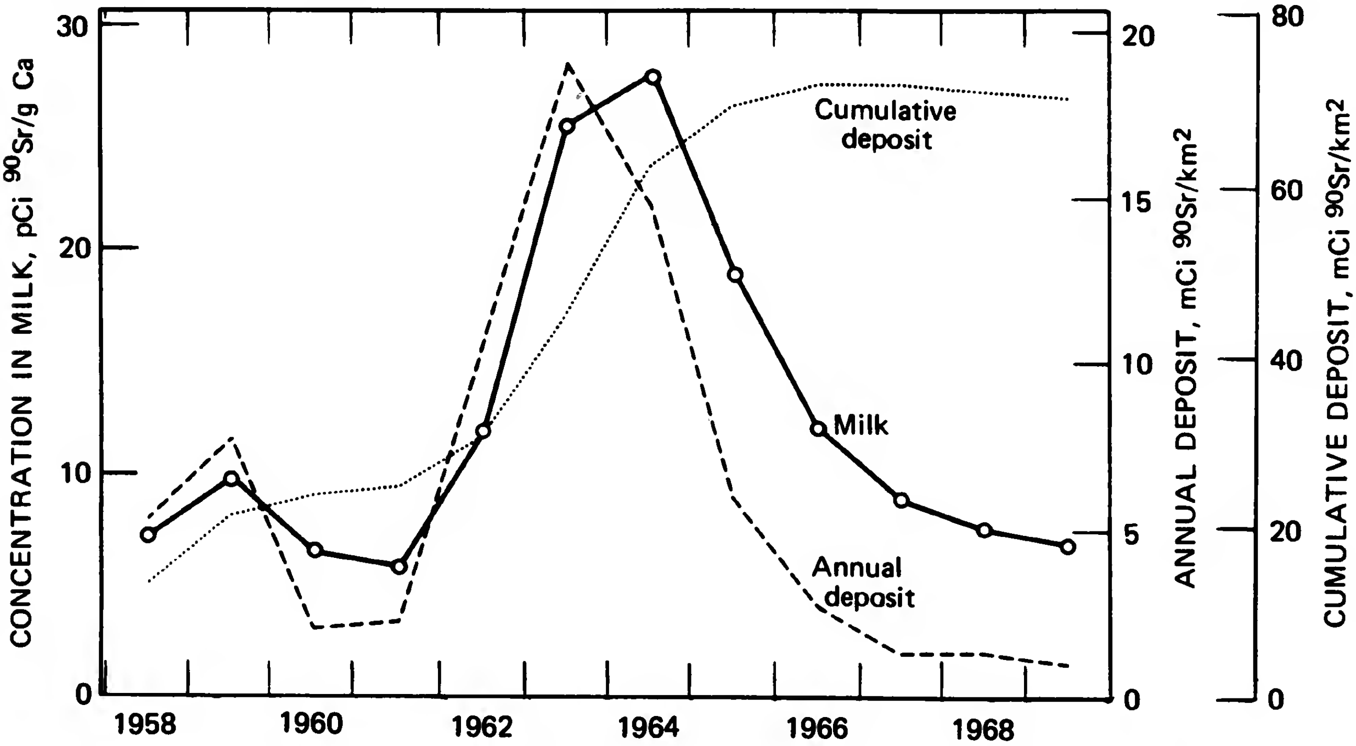


Fig. 1 Strontium-90 in fallout and milk in the United Kingdom, 1958 to 1969.

EFFECTS OF EXPOSURE TIME AND RATE

P. J. BOTTINO and A. H. SPARROW
Brookhaven National Laboratory, Upton, New York

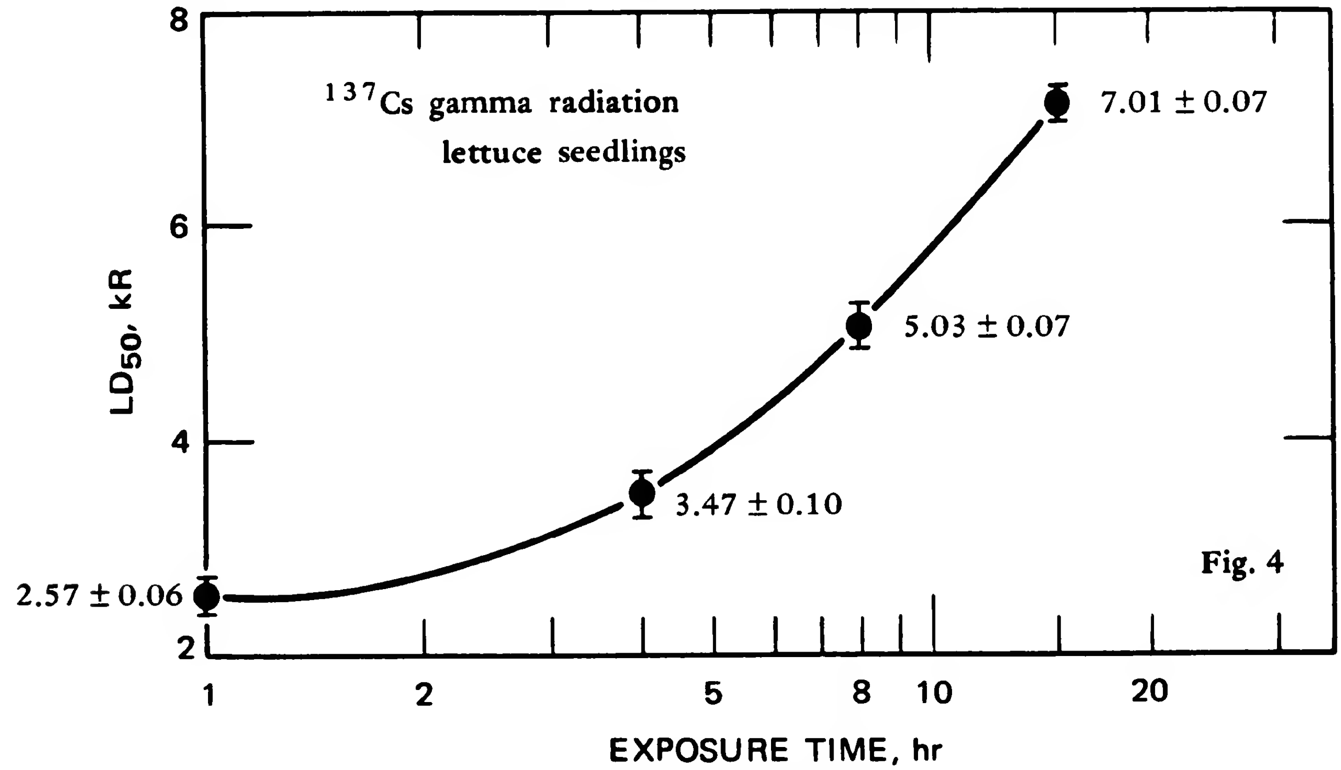


Fig. 4

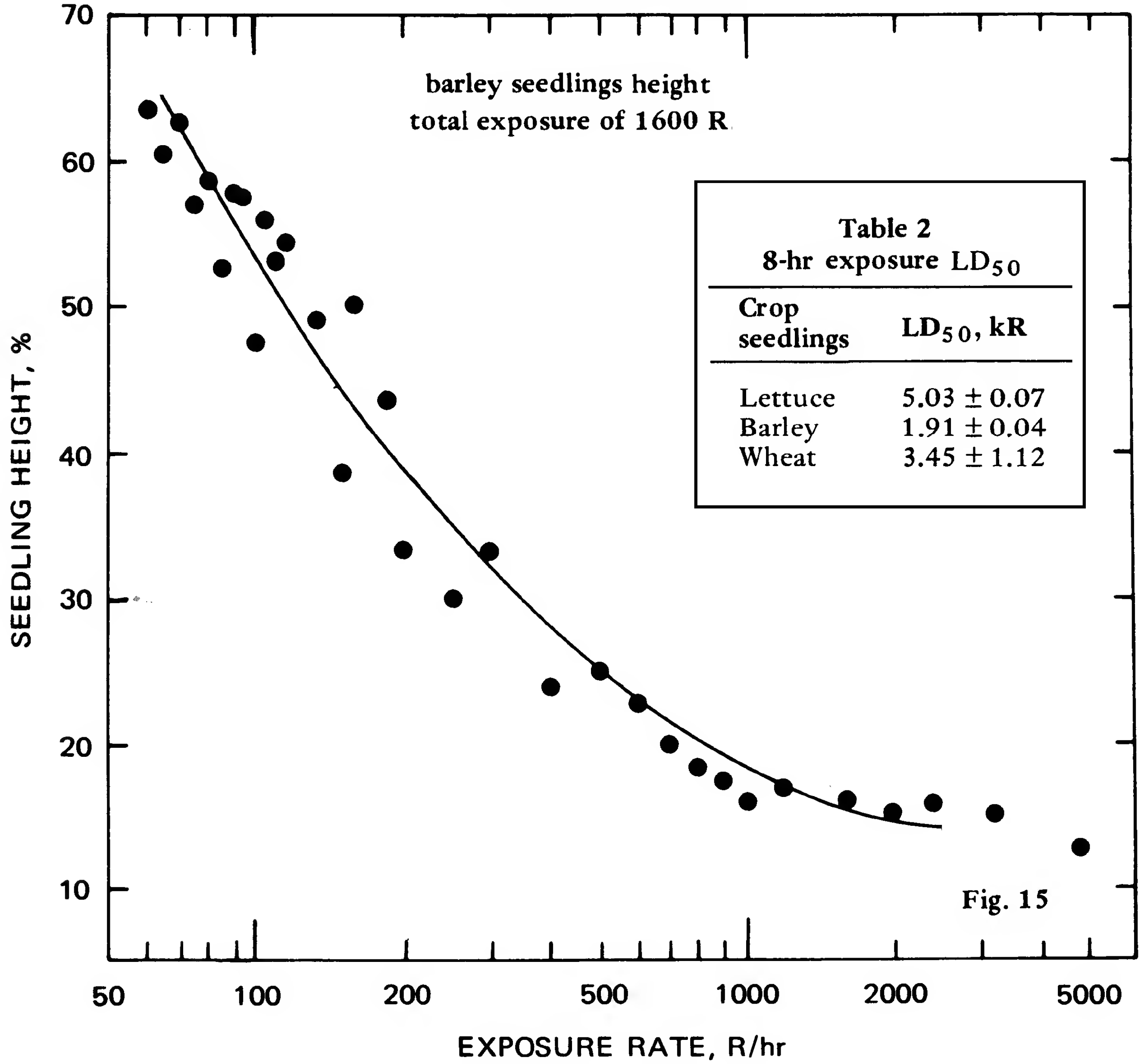


Table 2
8-hr exposure LD_{50}

Crop seedlings	LD_{50}, kR
Lettuce	5.03 ± 0.07
Barley	1.91 ± 0.04
Wheat	3.45 ± 1.12

Fig. 15

CONF-680410

The Proceedings of a Symposium on

DOSE RATE IN MAMMALIAN RADIATION BIOLOGY

April 29 - May 1, 1968
UT-AEC
Agricultural Research Laboratory
Oak Ridge, Tennessee

United States Atomic Energy Commission

A Relation of Irradiation Dose-Rate Effects in Mammals and in Mammalian Cells

J. L. Bateman
Medical Research Center
Brookhaven National Laboratory

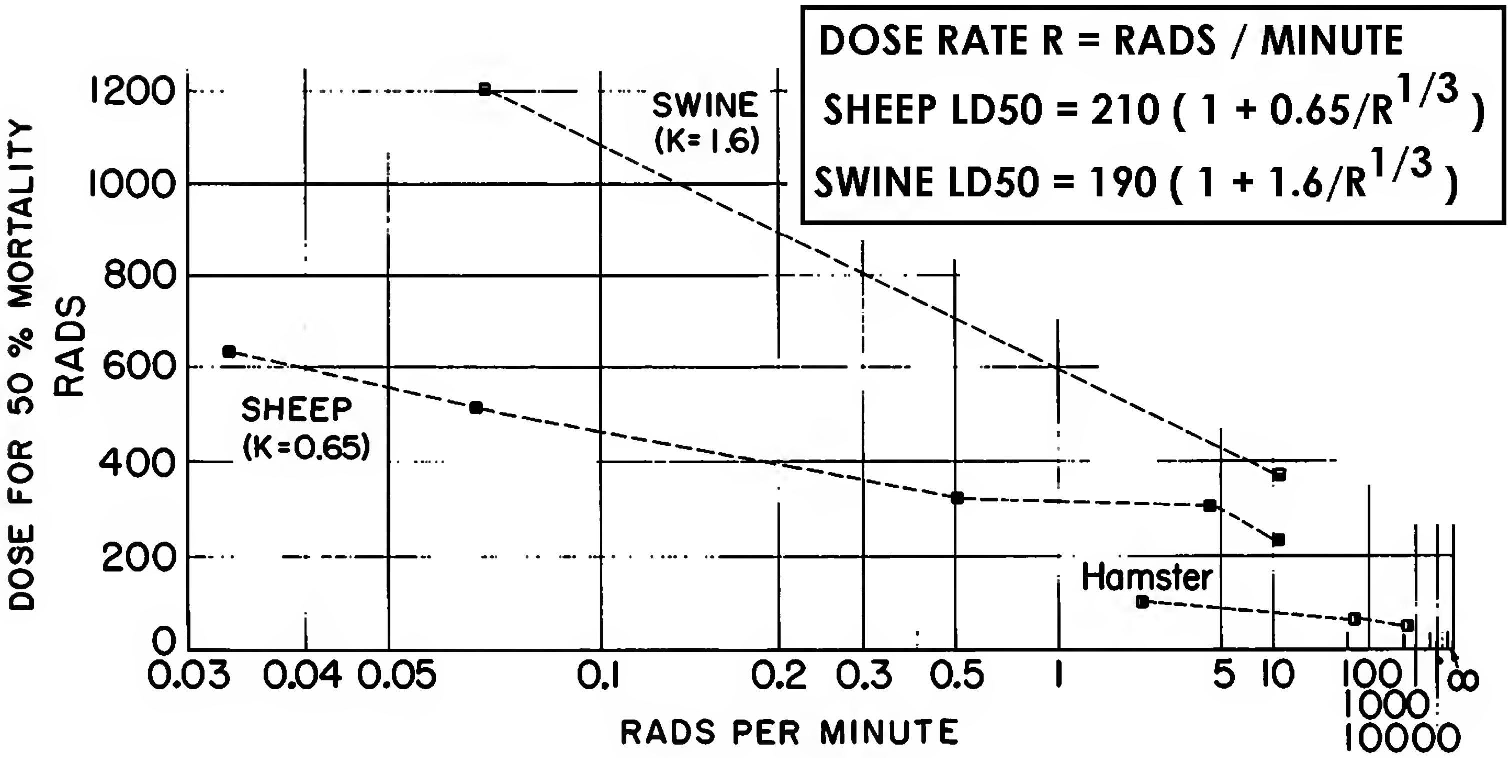


Fig. 1. Experiments in which the LD_{50} was found to be a linear function of the reciprocal cube root of dose rate.

Cobalt-60 DOSE-PROTRACTION ON RADIATION LETHALITY OF SHEEP

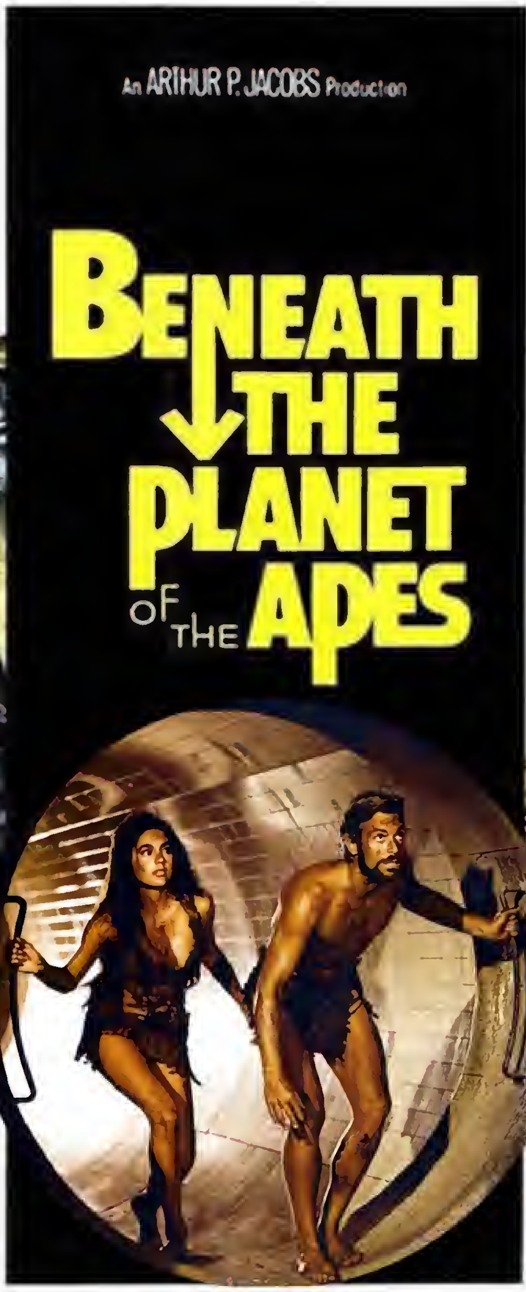
DOSE RATE (R/MIN)	METHOD OF EXPOSURE	MEDIAN LETHAL DOSE (LD50) MID-AIR DOSE (R)	MEDIAN LETHAL DOSE (LD50) MID-TISSUE DOSE (RADS)	REFERENCE
11.0	Bilateral	237	145	Hanks (1966)
4.35	Bilateral	318	194	Page (1968)
.5	Bilateral	338	206	Page (1968)
.06	Free-moving	495	302	Page (1968)
.033	Free-moving	637	389	Page (1968)

G. E. Hanks, N. P. Page, E. J. Ainsworth, G. F. Leong, C. K. Menkes, and E. L. Alpen, "Acute mortality and recovery studies in sheep irradiated with cobalt-60 gamma rays or 1 Mvp x-rays." Radiation Res. 27, 397-405 (1966).

N. P. Page, E. J. Ainsworth and G. F. Leong, "The relationship of exposure rate and exposure time to radiation injury in sheep." Radiation Res. 33, 94-106 (1968).

The bizarre world you met in "Planet Of The Apes" was only the beginning...

WHAT LIES BENEATH MAY BE THE END!



An army of civilized apes... A fortress of radiation-crazed super humans... Earth's final battle is about to begin– Beneath the atomic rubble of what was once the city of New York!

20th Century Fox

Starring JAMES FRANCISCUS · KIM HUNTER · MAURICE EVANS · LINDA HARRISON

Co-Starring PAUL RICHARDS · VICTOR BUONO · JAMES GREGORY · JEFF COREY · NATALIE TRUNDY · THOMAS GOMEZ

and CHARLTON HESTON as Taylor

Produced by APJAC PRODUCTIONS · Associate Producer MORT ABRAHAMS · Directed by TED POST · Screenplay by PAUL DEHN

Story by PAUL DEHN and MORT ABRAHAMS · Based on Characters Created by PIERRE BOULLE · Music by LEONARD ROSENMAN · PANAVISION® Color by DE LUXE®

G ALL AGES ADMITTED General Audiences

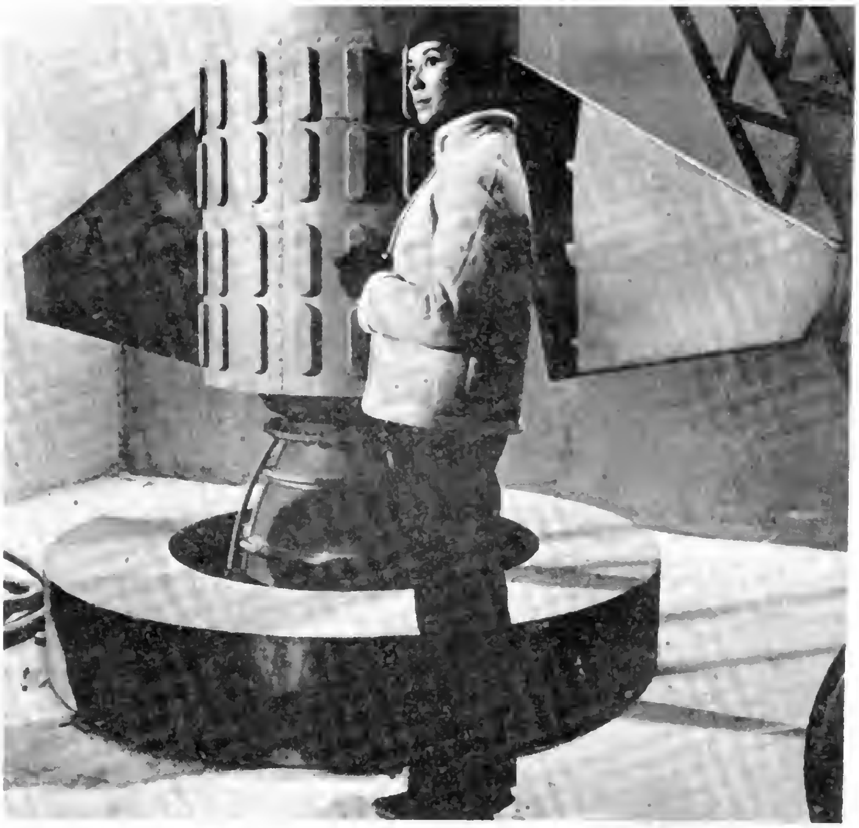


SAN SIMIAN SENTINEL

★★★★ FINAL

Vol. 1, No. 1 "THE TRUTH SHALL MAKE YOU FREE!" JANUARY 1 Weather: Snow Flurries

BATTLE FOR THE PLANET OF THE APES



Lovely France Nuyen is left in custody of the Alpha-Omega bomb, capable of completely obliterating Planet Earth. She is ordered to unleash it if the apes conquer the mutants in 20th Century-Fox' "Battle For The Planet Of The Apes."

The bomb takes its name from the Bible's Book of Revelations which enjoins: "I am the alpha and omega, the beginning and the end, the first and the last."

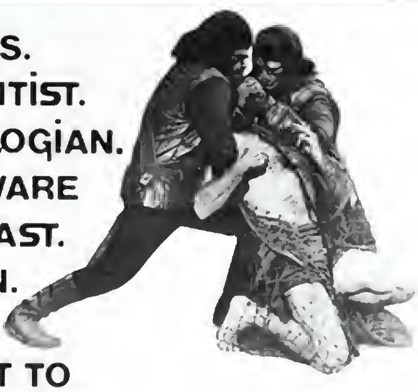
It is an awesome responsibility which Miss Nuyen accepts with greatest reluctance, but the threat is nonetheless real. The role is a far cry from Miss Nuyen's wistful film debut in "South Pacific" and succeeding parts such as her title role in "The World Of Suzie Wong."

JUST A SMALL SAMPLE

MISS NUYEN'S BOMB would be the final coup de grace for the planet, the world has already been ravaged by nuclear attack. Here Roddy McDowall, Austin Stoker and Paul Williams (L. to R.) enter the city reduced to a slag heap. They discover a few mutants, in passages far underground, have survived.

Civil defence workers must not ignore the anti-civil defence propaganda inherent in allegedly unbiased "science fiction films" like this 20th Century Fox publicity newspaper. H. G. Well's film version of "War of the Worlds" (gas war hysteria) appeased the Nazis!

This is dr. zaius.
brilliant scientist.
eminent theologian.
he warns: beware
of man the beast.
hunt him down.
cage him. for
man is a threat to
civilization on the



planet of the apes

This is dr. zira.
leading psychologist.
seeker of truth.
her experiments
on men have led her
to a secret about the
human animal. if she
reveals it, she will
be tortured.
for it will
endanger
civilization on the

planet of the apes

LATE FINAL

THE APE

No. 40463 FRIDAY, MARCH 1, 3978

EXCLUSIVE PICTURES OF CAPTURE OF HUMAN ANIMALS

"Intelligent Human" Dismissed as "Nonsense"

Young scientists, some even employed at the Academy of Ape Science, have for some time been propounding the astounding theory that certain human animals possess some measure of intelligence. The more precocious have even gone so far as to suggest that a small number of the human beasts may possess a standard of reasoning almost as highly developed as that of the Ape.

This absurd theory, which this newspaper believes is a heresy against the Ape Law and the writings of the Sacred Scrolls, has been advanced defiantly and with amazing bravado particularly by two young scientists, Dr. Zira and Dr. Cornelius. The couple claim that several discoveries at the scene of archaeological excavations to the West of the Forbidden Zone tend to prove that there was some significant human civilisation in existence on this planet more than two thousand years ago.

It is alleged that Zira and Cornelius have manufactured "evidence" to support their claims in reports to their superiors at the Academy on their studies of a particular human beast recently captured. The reports state that the man is able to make himself understood to the scientists by an intelligent form of sign language and even express the opinion that the beast may have been able to speak at one time. It is significant that the man-animal's ability to communicate by sound cannot be tested as he was wounded in the throat by Gorilla guards at the time of his capture.

"Many will think the so-called throat wound is a convenient excuse to prevent the immediate debunking of these ridiculous claims. To suggest that we can learn anything about the Simian nature from a study of man is sheer nonsense", stated a leading member of the Academy in an exclusive interview this morning.

The official declined to comment further on the grounds that the two scientists mainly concerned were at present appearing before the National Tribunal on charges of heresy arising from their continuing to maintain these views after repeated warnings from the Academy Council that they were dangerous, subversive and against Ape Law. The matter was, therefore, *sub judice*.

MAN IS A DANGER TO APE CIVILIZATION:- MUST BE EXTERMINATED — SAYS SCIENTIST

"Man — the human animal — is the most significant danger that our Ape civilisation has had to face in the last ten decades. The complete extermination of the species must be the primary concern of all those who hold dear the concepts and ideals of a planet where the Ape can live proudly, free from the spectre of famine brought about by the constant pillaging of our crops by the lowest of beasts — the human." This was the main message in a fighting speech delivered to young Simians at the National Academy last night by Doctor Zaius, Chief Minister of Science and Defender of the Faith.

Heresy Trial Opens

The trial for heresy of two young scientists from the Academy was opened today before the Tribunal of the Ape Nation.

The accused were Dr. Zira and Dr. Cornelius, indicted on several counts of heresy and violation of Ape Law and the teachings of the Sacred Scrolls by what the prosecution described as "insane attempts to cast doubts on our ancient laws and teachings by issuing what they purported to be evidence that the human animal is an intelligent creature".

The Tribunal consisted of the President; Doctor Zaius, Minister of Science and Chief Defender of the Faith and Doctor Maximus, Commissioner of Animal Affairs.

Dr. Zaius, Minister of Science and Chief Defender of the Faith

Dr. Cornelius

In opening the case against the two defendants, Doctor Honorius said that it was scientific heresy that was in fact on trial. The State's case was based on the first Article of Faith — that the Almighty created the Ape in his own image; that he gave him a soul and a mind; that he set him aside from the beasts of the jungle and made him Lord of the Planet. The proper study for Apes was Apes.

"But these young cynics", he said, indicating the defendants, "have chosen to study man. They are perverted scientists who advance an insidious theory called evolution."

Many Captured Near Forbidden Zone

Acting on the orders of Police Chief Marcus to show no mercy, the Apes ruthlessly clubbed or shot to death any humans who offered resistance or tried to escape into the Forbidden Zone, although the primary purpose of the raid was the capture of both male and female human animals to be used as subjects for experiments by our scientists. Despite the number killed, many humans surrendered without a fight and were taken into captivity.

FEMALE HUMAN SELECTED FOR GENETIC EXPERIMENTS

SIMIA, Friday.

Although many human animals were killed in this morning's raid, the main object — the capture of humans of both sexes for scientific experiments — must be considered a tremendous success. More than thirty of the beasts were made captive, many of them prime female specimens considered ideal for study by our scientists.

A number of professors and other learned Apes at the Ape National Academy have for some time been specialising in such experiments, aimed at increasing our present scant knowledge of the origin and evolution of this lowly species and to disprove, once and for all, the heretical theory that the Ape is descended from man.

The female human chosen for scientific experiments.

Dr. Zaius

Brilliant Scientist Dr. Zaius Advocates Extermination of Humans

Young Simians were enthralled last night at the National Academy by an address by Dr. Zaius, Chief Minister of Science and Defender of the Faith. In a stirring speech advocating the complete extermination of the human animal, Dr. Zaius urged his young listeners to take their share of responsibility in clearing the planet of what he called "the greatest menace to our Ape civilisation in the last ten decades".

"Beware the beast man", said Dr. Zaius, "for he is the devil's pawn. Alone among God's primates he kills for greed. He will murder his brother to possess his brother's land.

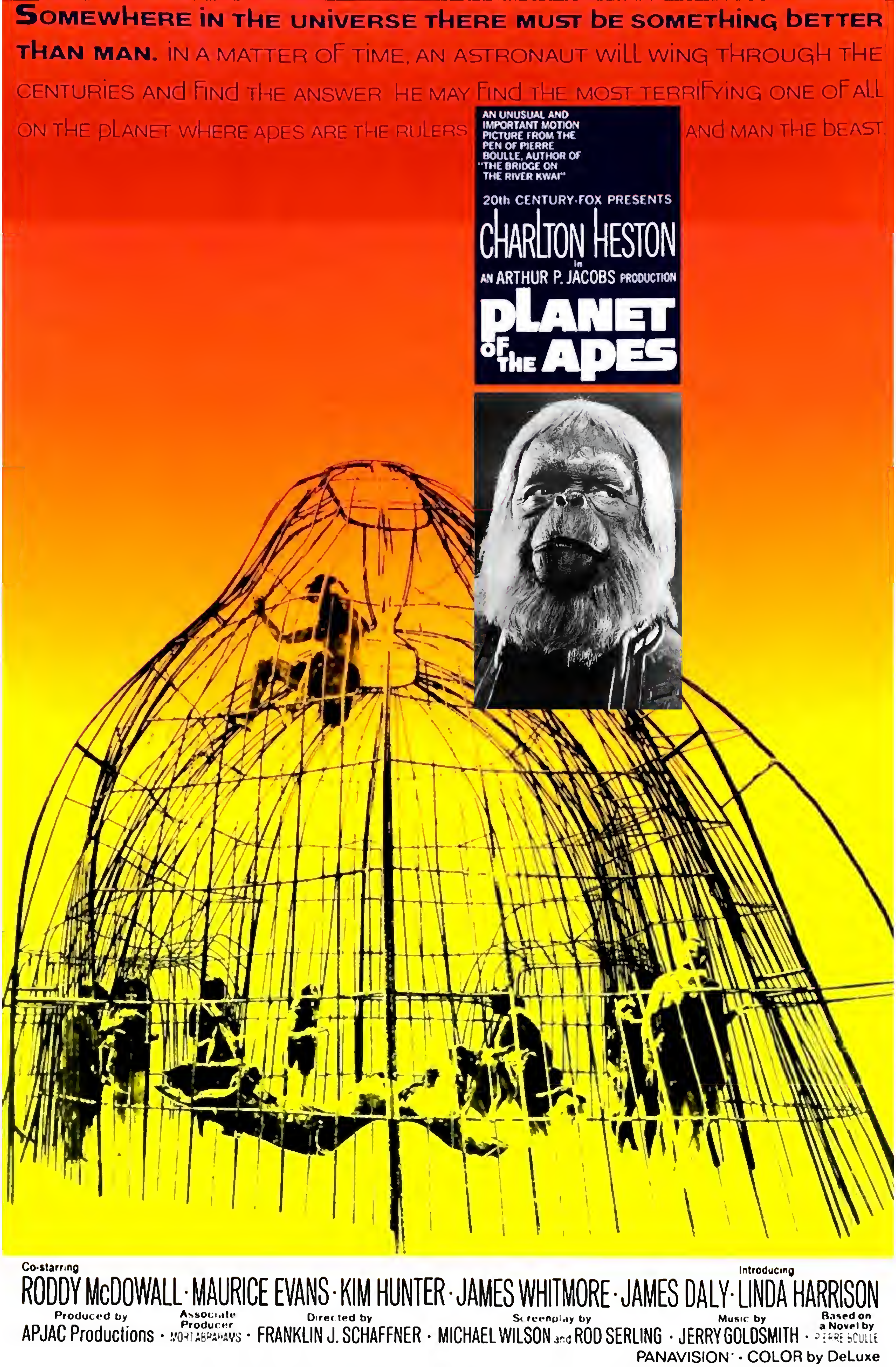
"Let us prevent him breeding in great numbers, for he will make a desert of his home and of yours. Shun him. Drive him back into his jungle lair — or more appropriately, and this I urge with all my ape instincts, exterminate him completely, for he is the harbinger of death."

In concluding his address amid rousing cheers, Dr. Zaius said that it was the duty of every section of Simian society to take part in the fight to rid our planet of the human species.

Marcus, Head of our Security Police, who has been a long-time advocate of harsher and more drastic methods of dealing with the human animals, was on the scene of this morning's great round-up, directing operations.

DAMAGE BY MAN

Statistics issued today by the National Academy show that over the last ten years the damage caused by the human animals' unceasing quest for food has increased more than four hundred per cent. "If the present rate continues", said Doctor Zaius, reviewing the figures, "the Ape nation will find itself in a position where famine will be a very real danger. It is essential, in the interests of Simian survival, that the numbers of humans be drastically reduced. They breed too quickly, denude the jungles of food, migrate to the green belts and ravage the Simian crops."


SOMEWHERE IN THE UNIVERSE THERE MUST BE SOMETHING BETTER THAN MAN. IN A MATTER OF TIME, AN ASTRONAUT WILL WING THROUGH THE CENTURIES AND FIND THE ANSWER. HE MAY FIND THE MOST TERRIFYING ONE OF ALL ON THE PLANET WHERE APES ARE THE RULERS AND MAN THE BEAST.
AN UNUSUAL AND IMPORTANT MOTION PICTURE FROM THE PEN OF PIERRE BOULLE, AUTHOR OF "THE BRIDGE ON THE RIVER KWAI"
20th CENTURY-FOX PRESENTS
CHARLTON HESTON
in
AN ARTHUR P. JACOBS PRODUCTION
PLANET OF THE APES
Co-starring
RODDY McDOWALL · MAURICE EVANS · KIM HUNTER · JAMES WHITMORE · JAMES DALY · Introducing LINDA HARRISON
Produced by APJAC Productions · Associate Producer · Directed by FRANKLIN J. SCHAFFNER · Screenplay by MICHAEL WILSON and ROD SERLING · Music by JERRY GOLDSMITH · Based on a Novel by
PANAVISION · COLOR by DeLuxe

CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

HEARINGS

BEFORE THE

JOINT COMMITTEE ON DEFENSE PRODUCTION CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

SECOND SESSION

APRIL 28, 1976

Printed for the use of the
Joint Committee on Defense Production

U.S. GOVERNMENT PRINTING OFFICE

74-307 WASHINGTON : 1976

HEARING ON CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

WEDNESDAY APRIL 28, 1976

U.S. SENATE AND
U.S. HOUSE OF REPRESENTATIVES,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

The committee met at 10:05 a.m. in room 5302, Dirksen Senate Office Building, Hon. William Proxmire, vice chairman of the subcommittee, presiding.

Present: Senators William Proxmire and John Sparkman.

Senator PROXMIRE. The committee will come to order.

Today's hearing inaugurates a review by the Joint Committee on our Nation's civil preparedness. It is the first such congressional review in over two decades.

By civil preparedness, we mean those mainly civilian measures by which we seek to protect the lives and property of our citizens.

This is the first function of any government. A government which cannot meet this fundamental test of defending its people and the national treasure is not likely to survive for very long.

In subsequent hearings, the committee will examine the adequacy of Federal, State, and local preparedness programs, including plans for fallout shelters, strategic evacuation, preparedness exercises and drills, civil defense stockpiles, and continuity of government. Likewise, the Joint Committee will inquire into the organization of the Government for preparedness. It will also review the Nation's industrial and economic preparedness in terms of the defense industrial base.

This is an especially timely undertaking. Over the past 2 years the United States has been moving from a declared nuclear policy of mutual assured destruction to one of flexible response, or limited nuclear war.

In the minds of some eminent strategists, this implies a lowering of the nuclear weapons threshold, a quickening of the trigger finger on the missile launch console, and an increased probability of uncontrolled nuclear conflict.

But to other equally qualified experts, this shift in strategic doctrine, this shift to larger numbers of more flexible, or more versatile and accurate weapons and control systems does not undermine deterrence of nuclear war; instead, it enhances deterrence.

Well, it can't be both ways and whenever you have such a complete divergence in expert opinion, it is time for a careful review of the facts.

2

These hearings are also timely in that there are increasing rumors of a civil defense gap, with the Soviet Union well in the lead.

In this year's annual report, Defense Secretary Rumsfeld stated that, and I quote:

> An asymmetry has developed over the years that bears directly on our strategic relationship with the Soviets and on the credibility of our deterrent posture. For a number of years, the Soviets have devoted considerable resources to their civil defense effort which emphasizes the extensive evacuation of urban populations prior to the outbreak of hostilities, the construction of shelters in outlying areas, and compulsory training in civil defense for well over half the Soviet population. The importance the Soviets attach to this program at present is indicated not only by the resources they have been willing to incur in its support, but also by the appointment of a deputy minister of defense to head this effort.

Now, the term "asymmetry" used by the Secretary sounds to a nonexpert like me like a four-bit word for "gap." We have heard a great deal over the years about gaps that never materialized or proved unimportant. Yet we have spent a lot of money to eliminate the nonexistent or the insignificant. It is for this reason that the committee last week published the declassified text of the 1957 Gaither Report which invented the first missile gap.

3

STATEMENT OF HON. PAUL NITZE, FORMER SECRETARY OF THE NAVY, DEPUTY SECRETARY OF DEFENSE, AND MEMBER OF THE SALT DELEGATION

Mr. Nitze. Mr. Chairman, my interest in the questions which this committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next 2 years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the survey, as Vice Chairman, I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

At Hiroshima and Nagasaki there was no air-raid warning and very few people availed themselves of the crude civil defense facilities which were available. Most of those that did, even at ground zero, in other words, directly under the explosion, which was at the optimum height of burst, survived. The trains were operating through Hiroshima 2 days after the explosion.

Let me paraphrase from an interchange I had in 1960 with Colonel Lincoln, head of the faculty at West Point, on this subject:

The Russians are careful students of Clausewitz. I do not believe they would ever ignore either the danger that a war once started might escalate to the full violence which the pure theory of war might indicate; on the other hand, they would never forget that war is a tool of policy and that every effort must be made to avoid letting it so escalate.[1]

[1] In this connection the following quotation from *Communist of the Armed Forces* in November 1975 is pertinent: "The premise of Marxism-Leninism on war as a continuation of policy by military means remains true in an atmosphere of fundamental changes in military matters. The attempt of certain bourgeois ideologists to prove that nuclear missile weapons leave war outside the framework of policy and that nuclear war moves beyond the control of policy, ceases to be an instrument of policy and does not constitute its continuation is theoretically incorrect and politically reactionary."

On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

In conclusion, I would like to comment on this committee's print containing the Gaither Report of 1957.

I have now read that report for the first time in nearly 20 years. I am impressed—especially in light of the information then available to the Gaither committee—by the care and comprehensiveness of that committee's examination of the problems assigned to it for study. I note in contrast the cavalier imprecision reflected in the foreword prepared by this committee's staff.

It is not true that the Gaither Report ignored arms control, nor is it true that the report spoke of U.S. strategic inferiority as then a fact. To the contrary, the Gaither Report described the United States as then "capable of making a decisive attack on the U.S.S.R." In view of SAC's vulnerability "to a surprise attack in a period of lessened world tension," the Gaither Report also noted the U.S.S.R.'s capability to make "a very destructive attack on this country."

The report then observed, "As soon as SAC acquires an effective 'alert' status, the United States will be able to carry out a decisive attack even if surprised," and it anticipated that juncture "as the best time to negotiate from strength, since the U.S. military position vis-a-vis Russia might never be so strong again."

In attempting to disparage the Gaither committee's analysis, the staff foreword cites a subsequent estimate "* * * that at the time of the Gaither Report the Soviet Union probably had fewer than a dozen operational ICBMs." In fact, at the time of the Gaither Report—only a few weeks after the sputnik launching—the Soviet Union obviously had no operational ICBMs. The Gaither Report made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the U.S. Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions.

Summary Statement by the Honorable Paul H. Nitze

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I believe they will always pay close attention to the interrelationship of the offense and the defense and not ignore either side of the equation. I cannot believe they would so ignore the military core of war as to consider the type of controlled nuclear conflict discussed in some of the papers circulated by the Committee's staff where military targets are avoided and industrial targets are hit. On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

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It is not true that the Gaither Report ignored arms control, nor is it true that the report spoke of U.S. strategic inferiority as then a fact. To the contrary, the Gaither Report described the U.S. as then "capable of making a decisive attack on the USSR." In view of SAC's vulnerability "to a surprise attack in a period of lessened world tension," the Gaither Report also noted the USSR's capability to make "a very destructive attack on this country." The Report then observed, "As soon as SAC acquires an effective 'alert' status, the United States will be able to carry out a decisive attack even if surprised," and it anticipated that juncture as "the best time to negotiate from strength, since the U.S. military position vis-a-vis Russia might never be so strong again."

In attempting to disparage the Gaither Committee's analysis, the staff foreword cites a subsequent estimate "* * * that at the time of the Gaither Report the Soviet Union probably had fewer than a dozen operational ICBMs." In fact, at the time of the Gaither Report—only a few weeks after the Sputnik launching—the Soviet Union obviously had no operational ICBMs. The Gaither Report

made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions. Thereby the Report became a factor in stimulating an enormous effort on the part of the U.S. to move ahead with pertinent strategic programs. In those years the rate of expenditure on strategic programs was, allowing for inflation, about two and a half times the present rate. For all the great expense, the program was a bargain when considered against the calamitous potential consequences of permitting the strategic relationship to become unstable to the detriment of U.S. security and with increased risk to the maintenance of peace.

The Report placed first priority on the military measures necessary to maintain strategic stability and high quality deterrence. It placed a lower priority on those measures necessary to ensure survivability of the population in event deterrence were to fail. The two classes of measures are, however, interrelated.

STATEMENT OF HERMAN KAHN, DIRECTOR, HUDSON INSTITUTE

Senator Proxmire. Mr. Kahn.

Mr. Kahn. It is customary to start one's testimony with a statement of qualifications. Let me instead start with a disqualification.

I haven't really been spending very much time in the military field since 1965, but I started to go back last year, and I am now in the middle of reacquainting myself with the issues.

I might say though that comparing today's discussion to the sixties, there has been very little substantial improvement. In fact there have been some retrogressions. This both disturbs and surprises me.

Let me start by agreeing with Paul on two issues. The chairman just stated we can't have both increased and decreased deterrence. I believe that there are many measures which can go in both directions.

There are many measures which increase deterrence in one scenario or context, and decrease deterrence in another scenario or context. In particular, if one focuses on this abstract war, what Paul referred to as a pure military war, or a surprise attack out of the blue directed against civilians, then it is terribly easy to do many things which will decrease that deterrence.

But since I tend to feel we have, relatively speaking, too much deterrence of this situation I do not object to decreasing the deterrence of surprise attack out of the blue in favor of increasing deterrence in other situations. In fact there has been much too much attention to this simple situation. I know back in 1960, a number of polls were taken by Tom Schelling, by Weapon Systems Evaluation Group (WSEG) and others. In these polls analysts were asked "If a war occurred, what scenario do you think would have preceded the war?"

Almost universally, they agreed there would have been a very tense situation, say bombs bursting in Europe, and then either an attack by the Soviets because they got into serious trouble, an accidental war, or an attack by the U.S. All the analysts agreed that a surprise attack out of the blue, directed at cities, was far and away the least probable way that a war was likely to start.

And yet they all also agreed that 90 percent of their personal studies and effort went to that case and the other 10 percent or so went into a study of a surprise attack out of the blue which hit military bases. In other words, the analysts agreed, that even though they were able

to choose their own subjects of study, they were spending almost all of their time on scenarios which, in their judgment, were not probable or important. They simply were the easiest things to study and talk about.

[Additional remarks:]

Many analysts are still doing this, but do not seem to know that this emphasis distorts the realistic priorities.

Now, when we looked at civil defense in 1960—or today—it was really almost impossible to protect the population against a surprise attack directed against them. We found that it was also impossible to protect an economic base for massive war production against a surprise attack directed against the economic base.

Therefore, we did not ask ourselves, as a high priority, what does civil defense do for these objectives in these scenarios.

However we did not stop there. We went on to ask ourselves if there were any other roles for civil defense.

It seemed to us that there were a large number of roles. All of them tended to be second or third priority but still terribly important. When people said, "But that doesn't do any good in the first priority situation," we answered, "We don't care."

The first, perhaps the most important role, is to protect people when they are not targets. I am prepared to believe that doing this decreases deterrence, but I am willing to do it anyway.

I know when I examine the problem of attacking the Soviet Union that I want to preserve Moscow and Leningrad, my two biggest assets, and anything they do to make Moscow and Leningrad safe from becoming bonus targets improves my ability to plan war against the Soviets. Moscow and Leningrad are important to the Soviets and they are probably willing to do that. Deterrence is not the sole objective of policy.

In a book called *On Thermonuclear War* which I published in 1960, we mentioned what we called the Doomsday Machine was the highest possible deterrent, yet nobody wanted it. I might also mention that I made clear, in that book, that we didn't think there was any missile gap. In fact, just to go back over a little history of that, most people's recollection of the debate of that period tends to be wrong.

It is not true that the Democrats raised the issue of a missile gap against the Republican administration. That was a Republican statement. The Republicans predicted the Russians would have 300 missiles by 1960. But at the same time, the Republican administration said this wouldn't make any difference, because we had 2,000 bombers and they were more important than 300 missiles.

The great contribution of the Gaither Report, as Paul just said, was to make clear that if the Soviets had 300 missiles and we did not have any kind of warning system, then we might not have 2,000 bombers, because they could be destroyed by a surprise attack while still on the ground.

I also made clear, that while the Soviets probably would not have 300 operational missiles in 1960, if they did have them, we would be in trouble—that is, despite the predictions by the Republican administration we did not think they had such a force—but we were not sure.

What does one do when the other side may be able to do something in the near future and if one waits until he is certain before reacting, it is too late, while if one reacts early it may turn out to have been unnecessary?

Let me also make a remark about a release I saw from this committee which listed a series of predicted gaps which did not occur. In at least half the cases, people were rather clear that the gap might not occur, but they were not sure.

[Additional remarks:]

But they felt they had to worry about it ahead of time and even make some preparations because they could not afford to wait until all the facts were in.

Let me ask a question: What do you do if the other side exhibits a weapon system and has the production capability? You are not quite sure what he is going to do. Do you wait until he does it or do you worry about it?

In general this is a very complicated issue. In some cases, we almost have to make preparations ahead of time, even though they may be wasted. In other cases, we should wait until we are more sure; in still other cases, one just hopes for luck. But one should not, in my judgment, downgrade responsible officials who get concerned under such circumstances.

I might also draw attention to some studies done by Albert Wohlstetter. It is pointed out in these studies that in most cases, we have underestimated rather than overestimated U.S.S.R. future capability. I will ask that this report be sent to the committee.

If you look at the record, there has been more a problem of underestimation than overestimation. This is true in terms of the number of missiles the Soviets have had over time and in terms of Soviet capability on all kinds of other issues. We tend to remember the discussion when some hysterical people overstate the problem; then it turns out to be wrong. I would argue this is not at all the characteristic problem.

Let me turn to the major point I wanted to make today. I would argue that the scenario I worry about as the most probable scenario, is also the scenario which is least discussed. This is the case where there is opportunity for significant or even all-out mobilization before major thermonuclear attacks against the cities occur.

There are two recent and useful historical examples which illustrate this concept, the Korean War and World War II.

In June 1950, Congress was debating whether the budget should be $15, $16 or $17 billion. The previous year it had been $13 billion. A number of distinguished witnesses testified that $18 billion would strain the economy, but $16 billion was all right. North Korea marched on South Korea, and within 1 year, Congress authorized $60 billion, an increase by a factor of 4.

This was totally unexpected and totally changed the strategic problem. One should note that it would not have been possible to fit into even an $18 billion budget hardly any of the weapons systems we have procured since World War II. One could not have bought a Sage system, a B–47 system, a B–52 system, a Nike Hercules system, a Polaris system, and so on. None of these systems would have been feasible at the $5 or $6 billion budgets per service which were, roughly, current at that time.

As a result of this authorization, the Air Force budget was increased by about a factor of 5. The other two services had an increase of about 3. As a result, a whole new range of possibilities opened up for the services.

I can easily envisage a scenario for crisis in the future which involves military budgets of $500 billion or more. That would change, if you will, the whole character of strategic planning. I do not expect any such situations to arise with high probability, but I do not consider it paranoia or unwise to prepare for such situations.

Probably an even better prototype for the situation we are thinking about is pre-World War II. After World War I, much of the world became sick of war, and war became "unthinkable" to most people, particularly in the victorious "Allied Powers." Strategists and publicists talked about poison gas and knock-out blows; they thought all the capital cities would be destroyed by poison gas in the first few days of a war. They did not understand the idea of limitations in warfare—of mutual deterrence even after hostilities have broken out.

When Hitler got elected in 1933, people became interested in larger defense budgets. Then he marched into the Rhineland and, of course, defense budgets increased slightly. Then there was the Anschlus and then Munich, and more substantial increases in military budgets. With the invasion of Czechoslovakia, everybody got deeply concerned. Then, finally, there was the invasion of Poland, the formal declaration of war and then 7 months of more or less "phony war." As a result there was opportunity on both sides for 7 months' of full-time war production, before the war really opened up.

We would argue that similar possibilities should be considered today. Nobody is interested in jumping into a nuclear war today. Nobody is going to want to execute the usual picture of nuclear war, in which each side presses every button and goes home. It is extraordinarily difficult to believe such a scenario.

It might happen. But I would be willing to bet, if this were a betting matter, 50 to 1 against it.

On the other hand, the situation might arise in which there was a declaration of war, followed by a phony war, or a serious confrontation in which there were credible threats of war. By the way, in such a confrontation, the following dialog tends to occur.

Both sides are saying to the other side, "There is absolutely nothing at risk which justifies this terrible danger to which we are subjecting each other and the rest of the world. It is clear that whatever we are arguing about is simply not worth the risk of a thermonuclear war. Therefore, one of us has to be reasonable—and it isn't going to be me."

That is, by the way, a terribly persuasive argument.

At this point, each side is trying to explain why the other side should be reasonable. You don't have to have a great defense to do that. All you have to be able to do is say, "I believe my defense establishment is better than yours, in important ways."

I can imagine the Russians telling us. "You are telling us the money we spent on our defense establishment does us no good, but we spent it because we thought it does do good. We believe that this defense establishment of ours works. You don't, but we believe it does."

If you can get that point across, you are going to put great pressure on the other side to back down.

Senator PROXMIRE. Very strong chance of what? I missed that.

Mr. KAHN. If we believe that they believe they have confidence in their establishment, we are going to back down, whether or not their

confidence is justified, because we would be destroyed almost as much as a result of their mistaken belief as by a correct one. If the other man can give you a credible picture, that he believes he has a serious edge over you, then even if he does not objectively have that edge, you may be in trouble.

That is even more true for allies. If they think the other side believes it has an edge, the allies are going to hedge. Finally it is even more true for neutrals that in a bargaining situation the strategic balance is very complex (which should be an obvious point) and the outsider is likely to be excessively influenced by appearances. Who strikes first and how many are dead in each city are almost irrelevant to many of these issues.

Finally, a last point. When we write scenarios for nuclear war, we find it difficult to write a credible scenario which doesn't involve months or weeks of warning. I would guess we are as good at writing scenarios as anybody in the world. We have certainly written as many.

I want to warn the committee, on the other hand, that when we looked at World War I, we didn't find that scenario plausible. The mere fact we can't write a plausible scenario for a war doesn't mean it can't occur, because one can find historical examples to the contrary.

Nevertheless, every scenario we write for nuclear war involves days, weeks or months of tension. Evacuation, last moment mobilizations are extraordinarily possible. By the way, evacuations occur not as a result of secret intelligence or in any attempt to try to outrun the missiles or the bombers. The *New York Times* and the *Washington Post* provide the warning perhaps days before the attack. People or governments then get frightened and decide to decrease their vulnerability to attack. The idea is, can you exploit such warning if it is printed in the papers?

[Complete statement follows:]

Summary Paper and Briefing Notes on the Potential of the Defense Mobilization Base Concept by Herman Kahn, William Brown, and William Schneider, Jr.

This submission is the responsibility of the authors and is not to be construed as representing any official opinions of the Hudson Institute or any other associated individuals or agencies.

PREFATORY NOTE

The following paper represents a summary of studies developed by the staff and consultants of the Hudson Institute more or less continuously over the last fifteen years although naturally it focuses more intensively upon recent work—in particular, a summary of a report on the concept of mobilization warfare by Herman Kahn and William Schneider, Jr. Most of Hudson's program of civil defense and mobilization base studies has been accomplished under the direction of William Brown, Herman Kahn and William Schneider, Jr. and at least half the Institute's personnel have participated in one or more of them. This particular submission was prepared as a joint paper by the three people named above.

MOBILIZATION WARFARE

1. The concept of mobilization warfare

The notion of mobilization in a nuclear age has the appearance of a contradiction in terms when arrayed against the conventional concept of mobilization. Mobilization has in general, been associated with the redirection of national resources, both human and material away from traditional civilian pursuits to support a defense effort. To some extent, it has been possible to conceive of a limited mobilization of military forces and associated national resources to support

limited political objectives although the more traditional perception has been associated with a general mobilization of the entire industrial might and armed forces of a nation.

The possibility of intercontinental strategic nuclear attack made possible through the development of ICBM's, missile firing submarines, and long-range bombers have made the initiation and conclusion of a nuclear conflict appear to be a matter of hours or days, and certainly not more than a few weeks in duration, making the traditional notion of mobilization appear to be as archaic and obsolete as the forces and weapons that had been in the past, mobilized.

This study is intended to advance the concept that mobilization is an important component of strategic nuclear conflict, and, we will argue, is likely to be the prototype of any U.S.-Soviet nuclear conflict should such a conflict occur. The concept can be most simply characterized from the perspective of the following simple generalized scenario: During a period of intense political crisis between the U.S. and the Soviet Union, both sides fear that a nuclear war may actually occur. However, neither side is willing to risk the consequences of a nuclear war with the existing levels of forces and defenses (military and civilian). As a consequence, each of the parties attempts to develop on a frantic basis, a very large-scale effective nuclear offense and defense capability which is associated with genuine fears about the possibility of a general war. The period of mobilization during and after an intense political crisis characterizes what we describe as "mobilization warfare." It is warfare in the sense of an intense and bitter competition of an accelerated arms race, but without the certainty that direct military action will occur. A plausible outcome of this scenario is that the side which mobilizes most effectively within a relatively brief period of time (say six months to two years) can achieve a dominant position capable of inhibiting the diplomatic efforts of the other.

The notion of "mobilization warfare" is not restricted only to strategic nuclear warfare. It is also applicable, for example, to a U.S.-Soviet struggle in Europe in which an intense political crisis raises the specter of an outbreak of conventional warfare between the two nations without the expectation that such a conflict would lead to a strategic or tactical nuclear exchange.

Perhaps the closest parallel to mobilization warfare during the nuclear era arose as a consequence of the Korean war. The ominous character of Soviet foreign policy following World War II culminated in the Soviet sponsored attack of North Korean forces against the Republic of Korea. The direction in Soviet foreign policy after World War II was not offset by any rebuilding of U.S. military power which had been rapidly dismantled after the end of World War II. However, when the Soviets authorized the attack on Korea, the change in U.S. attitudes regarding preparedness for a U.S.-Soviet strategic nuclear contingency was electric. One measure of the character of this concern, a measure characteristic of a serious mobilization, was the decision of the Congress to increase annual defense expenditures from $16 to the $60 billion authorized after the outbreak of the Korean war. This vast increase in authorized expenditure made possible a set of strategic programs that were simply not feasible within the prior U.S. defense budget. The new authorization made possible the B–52, the B–47, the Polaris Program, and Atlas Program and a host of related technological initiatives whose consequences are still influencing the shape of the U.S. strategic program today. It also developed a reasonable (for the time) civil defense program designed to move the more vulnerable portions of the home population rapidly to safer areas. As a consequence of this enormous build-up of strategic nuclear capability arising out of the concern over a possible U.S.-Soviet nuclear conflict in the early 1950s, the United States achieved for more than a decade a stark nuclear superiority over the Soviets. This superiority was so vast that in retrospect it appears clear that the Soviets were almost totally deterred from attempts to exert military power in support of their diplomatic objectives throughout the late 1950s and early 1960s.

In the early 1950s the Soviets also attempted to develop a larger strategic program, but were much less successful than the United States. This form of mobilization warfare, we argue, is more likely to become a "standard" mode of nuclear conflict with the Soviet Union than the commonly anticipated mode, namely a large-scale exchange of nuclear weapons.

Perhaps the most significant difference between traditional mobilization concepts and the concept of "mobilization warfare" that is the focus of this paper is that in a modern mobilization, the adequacy of a period of mobilization may be "tested" only in the sense that it can affect the perceptions of an opponent without

a shot being exchanged. Moreover, the period of mobilization in the modern era might be considerably more compressed and complicated than any which we have experienced in this century. In a very practical sense, the mobilization of Germany and the allied powers before the first World War was a traditional process which extended over a period of many years, although the most intense efforts took place after the initiation of the conflict. Similarly, the German and Japanese pre-war mobilization of their forces occurred over many years. In both cases, a large-scale and protracted conflict followed. Under modern conditions, a nuclear conflict between major powers is likely to be short compared to previous conflicts or to any period of mobilization.

The concept of mobilization warfare in a nuclear era implies relatively short reaction times with the ability to deploy major offensive as well as active and passive defensive systems which may be extremely costly and complex by any prior standards. Under such circumstances, it is entirely plausible that the U.S. strategic budget alone could constitute an expenditure of several hundreds of billions of dollars per year. Expenditures at such huge levels make possible a very wide range of military and non-military defense systems that could not be seriously considered with recent strategic budgets—less than $10 billion.

For example, potentially high grade missile defense systems employing lasers, particle beam technology and other advanced concepts for boost phase, mid-course, and terminal interception could, in principle, be procured under conditions of "mobilization warfare." The crucial determinants for acquiring such a capability lies in the prior research and development program and in proper institutional orientation toward a mobilization potential. The requirements of a "mobilization base" to support the notion of mobilization warfare is sufficiently different from the objectives of existing research and development needed to support current and near-term defense requirements that expenditures for a mobilization base should be partitioned from other R&D expenditures. The primary function of a mobilization base is to facilitate the shortening of lead times to procure highly effective strategic forces, active defenses, and civilian protection, should a decision to procure such a capability be made in a context that requires such a buildup be completed in an extraordinarily short period of time (short, that is, by the standards of recent experience). Under some circumstances, it is sufficient simply to have "paper plans" say, for the conversion of designated industrial potential from civilian to military uses. In other cases, where the requirements are more critical, and less easily adaptable to short-term changes, some limited development or prototyping may be necessary. In still other cases, particularly where the function is highly complex and likely to involve large numbers of both civilian and military personnel, such as an ABM or civil defense system, it may be necessary to conduct a limited deployment or field testing, and to develop the professional cadres who could support a vast expansion if and when circumstances require such expansion. The decision as to what elements of a potential U.S. strategic posture should be most extensively or rapidly developed would depend upon the contribution such efforts would make to reducing the lead times necessary to deploy the capability during a period of intense mobilization. The United States already possesses a substantial infrastructure for the rapid short-term expansion of U.S. strategic forces. With relatively modest expenditures, it should be possible to dramatically improve the ability of the United States to mobilize rapidly during an appropriate crisis to increase strategic nuclear forces, its active and passive defenses, and its general purpose forces without the protracted lead times that we have tended to become accustomed to over the past two decades.

2. A baseline mobilization warfare scenario

The implausibility of a U.S.-Soviet strategic nuclear exchange in recent politico-military circumstances has tended to obscure the fact that there are numerous possibilities for a major clash of interests between the superpowers; and consequently, for escalation.

The scenario proposed here arises out of the Achilles' heel of the Soviet Union, the behavior of their East European satellites, in this case, East Germany. Internal dissension develops beyond the control of the local and Soviet political and military leadership in East Germany to the point where large-scale border crossing into West Germany by deserting elements of East German armed forces involve the NATO nations. Unlike the standard escalation scenario where such events lead ultimately to a U.S.-Soviet nuclear exchange, the potential escalation, itself, becomes a force for restraint.

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TYPICAL STRATEGIC MOBILIZATION SCENARIOS

Of the four scenarios given below, the first two are history, the third used to be the great fear of NATO, and the fourth is probably the great fear of the Warsaw Pact.

1. The "phony war," 1940 (5 months):
(a) Pre-crisis arms competition (UK, France, Germany and the U.S.S.R.).
(b) A major series of political-military crisis—
Militarization of the Rhineland (1936);
Anschluss (Austria) (1938);
Sudeten crisis (1938–39);
War in Poland (1939).
(c) De-escalation and negotiation (antagonists began a rapid buildup fearing a resumption of full scale conflict).

2. Korea (1950–53):
(a) Pre-war politico-military crises—
Soviet invasion of Iran (1946);
Soviet takeover of East European nations (1945–48);
Berlin blockade (1948);
Soviet intervention in Turkey and Greece;
Soviet military buildup, post WW-II.
(b) Major turnabout in U.S. policy—
Factor of four increase in defense expenditures in 18 months;
Massive emphasis on strategic preparedness, especially active defense.

3. Successful Soviet attack on W. Berlin and subsequent de-escalation.
4. Uprising in East Germany gets out of control and escalates.

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CHARACTERISTICS OF A SPECIAL MOBILIZATION SCENARIO: A FORMAL DECLARATION OF WAR BY THE U.S.

1. The declaration would have solemn and especially great significance for our enemies, allies, and neutrals.
2. The information transferred would have:
(a) Unambiguous factual content of great importance;
(b) Undeniable implications and symbolism;
(c) Highly uncertain interpretations or implications.
3. Its existence would preempt "ordinary" crisis negotiation and deny the stability of any recent *fait accompli*.
4. In some extreme crises it could be temporizing—a declaration is not a spasm response—and lead to deescalation of actual fighting.
5. But it implies a rapid response to any increased use of force.
6. It tends to force a decision by allies to cooperate actively.
7. It would justify many peripheral actions (blockades, interdiction, property confiscation, internment of hostile aliens, etc.).
8. It would tend to unify the national response—and increase defense spending enormously through mobilization.
9. It would convey the unambiguous message that a *formal* peace treaty will be required to settle all the important issues.

ROLE OF RESEARCH FOR MOBILIZING ACTIVE DEFENSES

1. Missile defense probably would be the most important and expensive effort.
2. Lead-time reduction becomes extremely important.
3. A program is required to facilitate rapid massive procurement of mutually reinforcing systems—
Boost phase interception;
Mid course interception;
Terminal interception.
4. A capability may soon be needed to support a war in space.
5. A capability is required for integration into other—high priority strategic mobilization programs—
Air defense;
Civil defense.

Major research objective: design systems which are highly effective, mutually supporting and which can be rapidly deployed at high levels of expenditure.

Appendix I

Paul Henry Nitze

In the spring of 1969, Paul Henry Nitze was appointed the representative of the Secretary of Defense to the United States Delegation to the Strategic Arms Limitation Talks with the Soviet Union; a position he held until June 1974, at which time he resigned.

Mr. Nitze resigned from his duties as Deputy Secretary of Defense on January 20, 1969, a position he had held since July 1, 1967, succeeding Cyrus R. Vance.

Mr. Nitze was serving as 57th Secretary of the Navy when he was nominated by former President Lyndon B. Johnson on June 10, 1967, to become Deputy Secretary of Defense. He was confirmed by the United States Senate on June 29, 1967.

The late President John F. Kennedy nominated Mr. Nitze to be Secretary of the Navy on October 14, 1963. At that time he was serving as Assistant Secretary of Defense (International Security Affairs), having assumed that position on January 29, 1961. He began his duties as Secretary of the Navy on November 29, 1963.

Graduated "cum laude" in 1928 from Harvard University, Mr. Nitze subsequently joined the New York investment banking firm of Dillon Read and Company. In 1941, he left his position as Vice President of that firm to become financial director of the Office of the Coordinator of Inter-American Affairs.

From 1942–1943, he was Chief of the Metals and Minerals Branch of the Board of Economic Warfare, until named as Director of Foreign Procurement and Development for the Foreign Economic Administration.

During the period 1944–1946, Mr. Nitze was Vice Chairman of the United States Strategic Bombing Survey. He was awarded the Medal of Merit by President Truman for service to the nation in this capacity.

For the next seven years, he served with the Department of State, beginning in the position of Deputy Director of the Office of International Trade Policy. In 1948, he was named Deputy to the Assistant Secretary of State for Economic Affairs. In August, 1949, he became Deputy Director of the State Department's Policy Planning Staff, and Director the following year.

Mr. Nitze left the federal government in 1953 to become President of the Foreign Service Educational Foundation in Washington, D.C., a position he held until January 1961.

Mr. Nitze is Chairman of the Advisory Council of The Johns Hopkins School of Advanced International Studies in Washington, D.C., and also serves on the Board of Trustees of the University. He holds memberships on the Board of Directors of Schroders, Inc., in New York, and Schroders, Ltd., in London, The American Security and Trust Company of Washington, D.C., Northwestern Mutual Life Mortgage and Realty Investors of Milwaukee, Wisconsin, and is Chairman of the Board of the Aspen Skiing Corporation.

Herman Kahn

Herman Kahn was born in Bayonne, New Jersey, in 1922. He received a B.A. from UCLA in 1945 and an M.S. in physics from the California Institute of Technology in 1948. He was associated with the Rand Corporation before becoming in 1961 the principal founder and director of the Hudson Institute, a research organization studying public policy issues, with headquarters in Croton-on-Hudson, N.Y. His international reputation as a strategic warfare analyst or, as the *New Republic* put it, one of "the prophets of strategic reality," is based on his work at the Institute and on his books: *On Thermonuclear War* (1960), *Thinking about the Unthinkable* (1962), *On Escalation* (1965 and, revised Pelican

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Statement of E. P. Wigner [1] for the Joint Committee on Defense Production

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

THE EFFECTIVENESS OF CIVIL DEFENSE

This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the U.S. Atomic Energy Commission.

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Are the U.S.S.R. and China the only countries with elaborate and well developed civil defense systems? No—most of the peace-loving countries also have such systems, based on blast shelters, and their yearly expenditures per person on such defense is about 15 times greater than ours. This has been, so far, about 40¢ per person a year. Incidentally, the Swiss civil defense repeats our President Kennedy's message: (Civil defense) "is insurance we trust, will never be needed"—its greatest accomplishment is, according to the Swiss, that it will *not* have to be used, that it will divert the aggressive instincts of possible opponents.

It is easy to conclude that an effective civil defense is not only desirable, it is also possible.

IS CIVIL DEFENSE NECESSARY?

What is the principal danger that threatens us in the present absence of an effective civil defense? It is the possibility of the U.S.S.R. evacuating its cities, dispersing their population, and then making demands on us, under the threat of a nuclear attack, approximating those made by Hitler or Czechoslovakia which led to the Munich pact. This left Czechoslovakia essentially defenseless.

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THE ARGUMENTS AGAINST CIVIL DEFENSE

The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort. One of the two arguments we now hear, the civil defense is too expensive, seems almost ridiculous. If Switzerland, Sweden, etc., *even China*, can afford the more costly, the blast shelter method, we with the highest per capita national wealth, can also surely afford the defense of our people. The other argument, in the words of one of the most learned opponents of civil defense, S. Drell, is that it would lead to an "escalation of the apprehension from the mood of today, vis-a-vis the dangers of a nuclear exchange between the U.S. and the Soviet Union." Should the apprehension of the danger not be greater now, where we have no effective defense, than it would be when we have such defense? Or is it proposed that we should lull the common people into ignorance of the true situation? It is remarkable also that the U.S.S.R. is not criticised for fostering the "apprehension" of its own people. One must conclude that the varying arguments against civil defense have little validity.

A FEW PROPOSALS RELATED TO OUR DEFENSE

The first change I would advocate is to stop maintaining that a nuclear war would be the end of mankind. Such a statement may give the impression to an opponent that he can achieve anything by threatening with a nuclear war. After all, he would argue, the opponent (that is us) will make any sacrifice to avoid the "end of mankind". Hence, if he is threatened with extinction he will give in, particularly if the threat comes from a party which does not believe that the war precipitated by him will lead to the "end of mankind". Instead of such a blatantly incorrect statement, it would be better to subscribe to Chuykov's doctrine that "knowledge and the skillful use of modern protective measures" will make it possible to provide effective protection. At least, we could adhere to Kissinger's earlier (1957) statement: "While it (civil defense) cannot avert the traumatic effect of vast physical destruction, its efficient operation may make the difference between the survival of a society and its collapse."

The second measure which I consider to be urgent is to establish better contact with the people at large. This makes it desirable for DCPA to expand its staff by the employment of people who can establish a contact with the population at large, who can speak and write the truth convincingly. One of the functions of these advisors would be to help the high schools to give instruction on the nature of nuclear explosions and the defense against the effects of these. This is a subject which is foreign to most present high school teachers, and the advisor could and should help them to acquire the necessary knowledge. After all, the Federal Government now intends to support the local schools and can well suggest that these contribute to the protection of the country. The high school instruction on civil defense—obligatory in the U.S.S.R.—would be very useful since, after all, we learn best when we are young and we learn most non-elementary facts from our teachers. But even more generally, the establishment of a close contact between those who protect our freedom, and those whose freedom is protected, would be very desirable; and acquainting people at large with the methods and effectiveness of civil defense would provide an avenue toward this goal. It may not be easy to find people who know about the methods and effectiveness of civil defense and who are also able and interested in communicating this and much other knowledge to the people at large, but every effort should be made to find such people and support them.

The last suggestion I wish to make is that the DCPA budget should certainly not be cut. It should steadily be increased until, in a few years, it reaches the per capita level of other peace-loving and non-expansionist countries, such as Switzerland, Holland, Sweden, etc. For reasons given in the rest of my statement, this would be of decisive importance for maintaining a valid, widely endorsed, and vigorous defense effort for our country—and it would support all freedom-directed nations. Their independence does depend to a certain degree on our strength and our ability to stand up for them. The examples of Hungary, Czechoslovakia, Poland—to mention only a few—show that such independence does not come freely.

Let me end on a bit more hopeful tone which is, however, as sincere as was the rest of my statement. This is the hope that an effective civil defense may not only protect our country and our freedoms, but it may

also lead to a more true peace than the present one, which is based on the fear of destruction. I hope such a peace in which no rulers are tempted to increase their domains will come into being!

STATEMENT OF GERARD C. SMITH [1]

I propose to discuss this morning some of the arms control implications of Vladivostok as well as certain related aspects of the current Defense budget submission.

I. THE VLADIVOSTOK ACCORD

At the start let me say that I put forward these ideas tentatively, not categorically. I question that anyone can speak with certainty about the slippery issues surrounding strategic arms and their control. I admit to a bias in favor of a very strong defense but I believe that arms control can also advance the security of the United States and the world whether or not there is some relaxation of tensions between the U.S. and the U.S.S.R.

The Vladivostok accord should not be judged in and of itself—but in connection with the limit on defensive systems (ABMs) agreed upon in 1972 and other American-Soviet agreements relating to arms control. It may help in judging the significance of Vladivostok to see that accord as part of a process that has been going on for more than five years. The general strategic dialog of the 1960s led to the specific SALT exchanges of 1969–72 at Helsinki, Vienna, Washington, and Moscow. Gradually the two sides developed somewhat better understanding of each other's strategic preoccupations. Concerns about accidental or miscalculated nuclear hostilities led to the first two SALT agreements in 1971—on measures to reduce the risk of outbreak of nuclear war and on measures to improve the Washington-Moscow direct communication link or "Hot Line." In 1972 there was the major breakthrough, the treaty limiting ABMs to two sites apiece, accompanied by the interim agreement to freeze offensive launches at the approximate levels of 1972. These were followed in 1973 by the Nixon-Brezhnev agreed principles for offensive arms limitation and in 1974 the ABM Treaty levels were reduced to one site apiece. At year's end the Vladivostok accord foreshadowed limitations on offensive systems which although of relatively short duration may be considered as a counterpart of the ABM Treaty. In judging this latest agreement one should consider the cumulative effect of the entire SALT process which hopefully can be considered as a preparatory stage for the natural next steps—reduction in offensive force levels which the sides are now committed to negotiate and some limitation on improvements in weapons characteristics. A total ban on ABM systems should also be reconsidered.

I would not favor interrupting the current Geneva negotiations by introducing a proposal for reductions. I do not believe that reductions are negotiable now. The Soviet position since 1968 has called for first a limitation and subsequently for reductions. When and if

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[1] Mr. Smith is the former Director of the U.S. Arms Control and Disarmament Agency and chief U.S. representative in SALT I. He is now in private practice with the law firm of Wilmer, Cutler, and Pickering. His statement submitted to the Joint Committee was originally delivered to the Senate Foreign Relations Committee in April 1975.

(Gross exaggerations, assuming Nevada desert type terrain with no thermal shadows by city skylines, no duck and cover, no clothing and fraudulent blast effects data which ignores Hiroshima's evidence)

APPENDIX III

U.S. CIVILIAN NUCLEAR FATALITY ESTIMATES [1] FOR VARIOUS COUNTERFORCE ATTACK SCENARIOS

Type of attack	Assumptions	Estimated fatalities
Comprehensive attack:		
Case 1, 60 percent destruction of military targets.	1 optimum height of burst and 1 surface burst warhead per each of 1,054 ICBM silos; pattern attack of SAC bases: unspecified attack on 2 SSBN support bases; good shelter posture.	3, 200, 000
Case 2, 60 percent destruction of military targets.	2 optimum height of burst warheads per each of 1,054 ICBM silos; no pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; poor shelter posture.	6, 700, 000
Case 3, 57–60 percent destruction of military targets.	2 surface burst warheads per each of 1,054 ICBM silos; pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; very poor shelter posture.	16, 300, 000
ICBM only attack:		
Case 1	2 550 kt optimum height of burst warheads per each of 1,054 ICBM silos.	[2] 4, 000, 000
Case 2, 42 percent silo destruction.	1 550 kt surface burst and 1 550 kt optimum height of burst warhead per each of 1,054 ICBM silos.	5, 600, 000
Case 3, 80 percent silo destruction.	1 3 Mt surface burst and 1 3 Mt optimum height of burst warhead per each of 1,054 ICBM silos.	18, 300, 000
Case 4	2 3 Mt surface burst warheads per each of 1,054 ICBM silos	[3] 20, 000, 000
Airlift attack: [4]		
Case 1	1 200 kt cruise missile warhead per each of 5 U.S. heavy airlift bases (Dover AFB, Del.; McGuire AFB, N.J.; Travis AFB, Calif.; Charleston AFB, S.C.; and McChord AFB, Wash.)	70, 000
Case 2	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases	210, 000
Case 3	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases uses offset targeting.	135, 000

[1] Department of Defense estimates as reported to the Senate Foreign Relations Committee, July 11, 1975, and published in "Analyses of Effects of Limited Nuclear War," pp. 12–24. Note that figures are fatalities only and not casualties and that attacks are restricted to military facilities (counterforce) rather than populated areas (countervalue). Shelter posture is a function of degree of hardening and the willingness of the population to use shelters.

[2] Under.

[3] Circa.

[4] Assumes allied victories in a European war supported by U.S. military airlift provide incentives for destruction of major American airlift centers.

Survival of the Relocated Population of the U.S. After a Nuclear Attack

FINAL REPORT • JUNE 1976 ORNL-5041

by

Carsten M. Haaland

Conrad V. Chester

Eugene P. Wigner

for

Defense Civil Preparedness Agency

Washington, D. C. 20301

OAK RIDGE NATIONAL LABORATORY

ADA026362

SURVIVAL OF THE RELOCATED POPULATION OF THE U.S. AFTER A NUCLEAR ATTACK

C. M. Haaland, C. V. Chester, and E. P. Wigner

ABSTRACT

The feasibility of continued survival after a hypothetical nuclear attack is evaluated for people relocated from high-risk areas during the crisis period before the attack. The attack consists of 6559 MT, of which 5951 MT are ground bursts, on military, industrial, and urban targets. Relocated people are assumed to be adequately protected from fallout radiation by shelters of various kinds. The major problems in the postattack situation will be the control of exposure to fallout radiation, and prevention of severe food shortages to several tens of millions of people. A reserve of several million additional dosimeters is recommended to provide control of radiation exposure. Written instructions should be provided with each on their use and the evaluation of the hazard. Adequate food reserve exists in the U.S. in the form of grain stocks, but a vigorous shipping program would have to be initiated within two or three weeks after the attack to avoid large scale starvation in some areas. If the attack occurred in June when crops on the average are the most vulnerable to fallout radiation, the crop yield could be reduced by about one-third to one-half, and the effects on crops of possible increased ultraviolet radiation resulting from ozone layer depletion by nuclear detonations may further increase the loss. About 80% of the U.S. crude refining capacity and nearly all oil pipelines would be either destroyed or inoperative during the first several weeks after an attack. However, a few billion gallons of diesel fuel and gasoline would survive in tank storage throughout the country, more than enough for trains and trucks to accomplish the grain shipments required for survival. Results of a computer program to minimize the ton-miles of shipments of grain between Business Economic Areas (BEAs) indicate that less than 2% of the 1970 rail shipping capacity, or less than 6% of the 1970 truck shipping capacity would be adequate to carry out the necessary grain shipments. The continuity of a strong federal government throughout the attack and postattack period is essential to coordinate the wide-scale interstate survival activities.

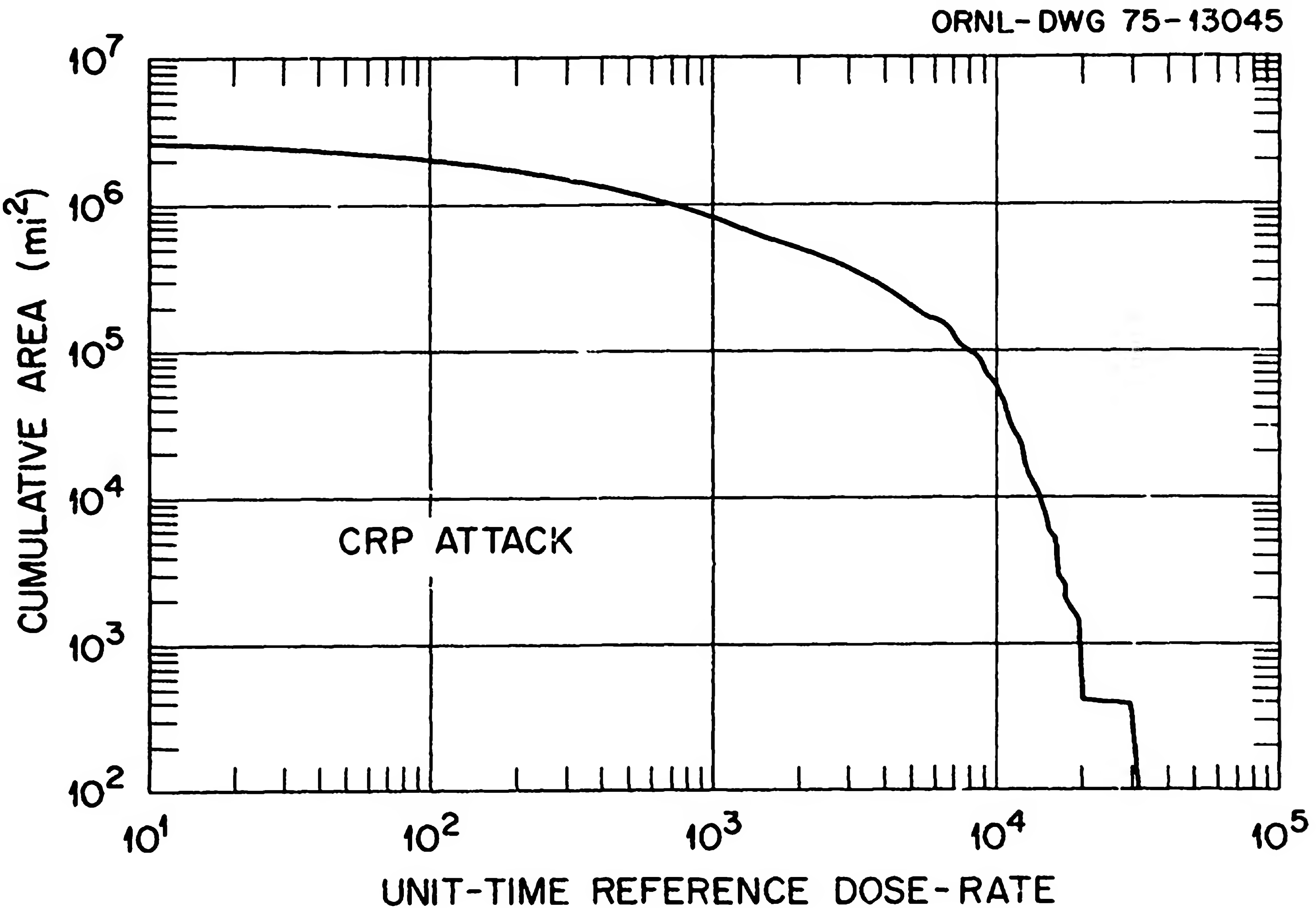


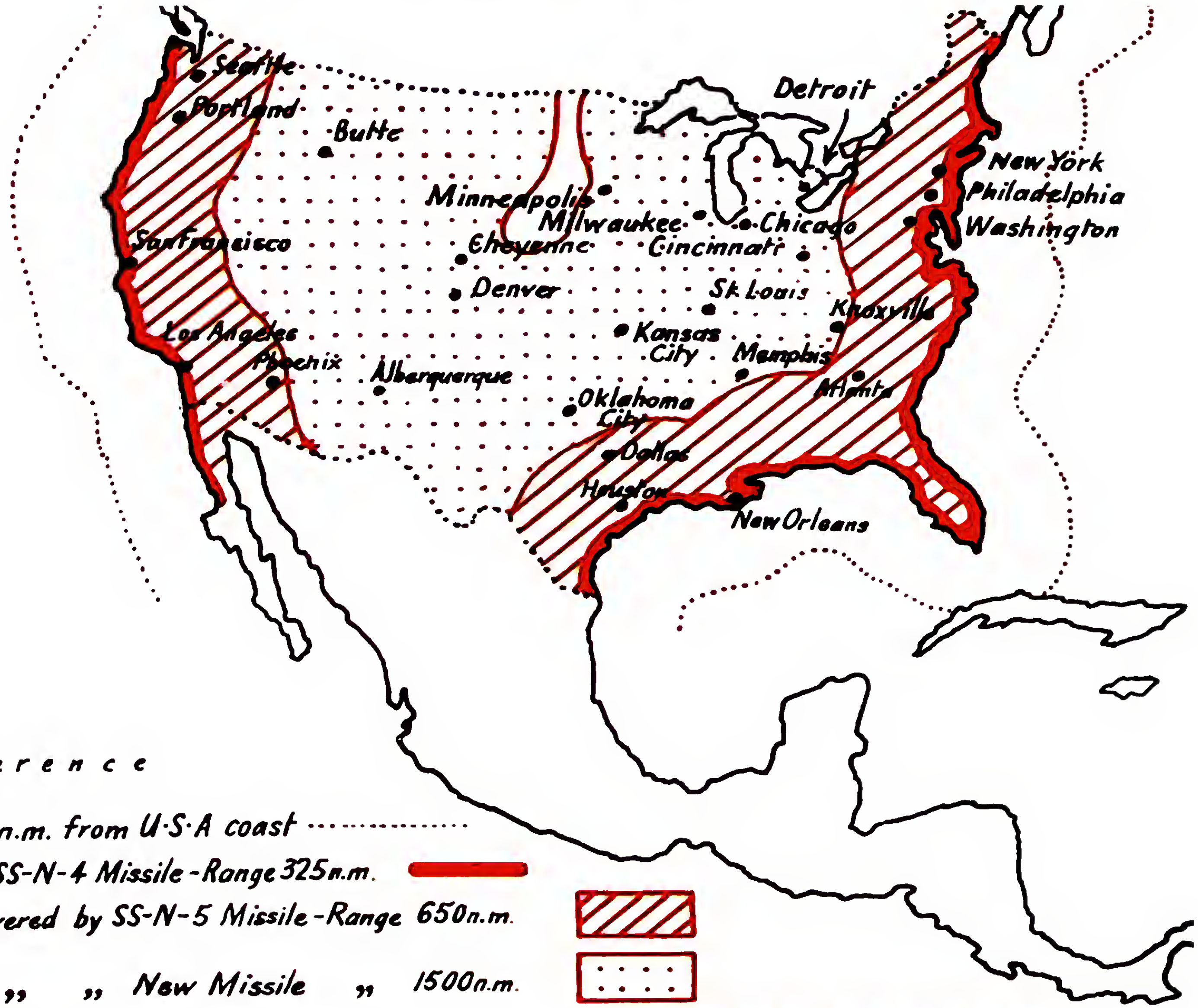
Fig. 4.2 Area of U.S. as a Function of Unit-Time Reference Dose Rate.

Appendix 2 to ANNEX 'A'
to J.I.C.(68) 4 (Final)

TOP SECRET

SUBMARINE LAUNCHED BALLISTIC MISSILES

COVERAGE of the U.S.A



Reference

Firing Line 300 n.m. from U.S.A coast ....

Area covered by SS-N-4 Missile - Range 325 n.m.

Additional Area covered by SS-N-5 Missile - Range 650 n.m.

" " " " New Missile " 1500 n.m.

TOP SECRET

Drawn by DI.58c(N). 159/67. Dec. 1967

CABINET OFFICE WAR BOOK

CHAPTER 2

ACTION IN THE EVENT OF AN ATTACK WITHOUT WARNING

1. It would be possible for a potential enemy to launch a full-scale nuclear attack against this country without any readily detectable preparations. We might therefore (if there had been no period of tension to alert us) have very little time - possibly less than an hour - in which to prepare.

2. Beyond the instant alerting of the Air Defence System and any nuclear retaliation forces, it is not considered practicable to make any detailed plans for such a situation.

3. Immediate action required by the Cabinet Office is given below, and further action would be decided upon ad hoc at the time.

Cabinet Office Serial No.	Corresponding Government War Book Measure	Action to be taken	Observations
(a)	(b)	(c)	(d)
		On receipt of information from Chief of the Air Staff that an attack on this country is imminent -	The Chief of the Air Staff will have made necessary dispositions to avoid loss of aircraft on the ground by enemy action. He will also have informed the Prime Minister, Secretary of the Cabinet and the Chief of Defence Staff.
CAB.1	Appendix Z. Serials Z.3 and Z.4	SECRETARY - (a) Confirm with the Private Secretary to the Prime Minister where Cabinet meeting is to be held. (b) Inform the following of events and of the location of the meeting - (i) Foreign Secretary (ii) Home Secretary (iii) Secretary of State for Defence (iv) Chief of the Defence Staff	
CAB.2	Appendix Z. Serial Z.5	SECRETARY - Proceed immediately to meeting with Prime Minister and other Ministers and Chief of the Defence Staff	At the meeting the Private Secretary to the Prime Minister will arrange for the latter to speak to the President of the United States.

ANNEX B to
CHAPTER 3

IMPLEMENTATION OF GOVERNMENT WAR BOOK MEASURES

Cabinet Office War Book Serial No.	Corres-ponding Government War Book Measure	Action to be taken	Remarks
(1)	(2)	(3)	(4)
CAB. 3	-	On receipt of any information which is considered by the Current Intelligence Groups to constitute a positive indication that an attack on this country is to be expected SECRETARY JOINT INTELLIGENCE COMMITTEE (JIC) - (a) Call immediate meeting of JIC, to which American and Canadian representatives are to be invited. (b) Warn - (i) Secretary of the Cabinet (ii) Defence Secretariat, Cabinet Office (iii) Secretary, Chiefs of Staff Committee (or, out of working hours, Defence Operations Centre Duty Officer, MOD)	Intelligence procedure on receipt of a possible indicator is set out in detail in Chapter IV of the JIC Watch Manual (JIC(66) 6 (Final))
CAB. 4	Appendix Z Group A Serial 1.1	If JIC agree that a nation of the Soviet bloc is about to engage in hostilities with this country - SECRETARY, JIC - Inform - (a) Private Secretary to the Prime Minister (b) Secretary of the Cabinet (and Defence Secretariat, Cabinet Office) (c) Home Secretary (d) Foreign Secretary (e) Secretary of State for Defence (f) Chief of the Defence Staff (g) United States and Canadian Intelligence Authorities (h) Standing Group and NATO Supreme Commanders, as appropriate	GSPS would, on receipt of this warning, arrange a secure speech and/or telegraph circuit between the Prime Minister and the President of the United States (see Serial CAB 14). SACEUR and SACLANT would in any event be informed

October, 1966

ANNEX B to
CHAPTER 3 (Contd.)

Cabinet Office War Book Serial No.	Corres-ponding Government War Book Measure	Action to be taken	Remarks
(1)	(2)	(3)	(4)
CAB. 13	Part II Serial 1.9	On receipt of notification from JIC that an attack is to be expected SECRETARY - summon a meeting of the Cabinet to which the Chiefs of Staff are invited.	Details of the where-abouts of Cabinet Ministers are in the Duty Officer's box
CAB. 14	Part II Serial 1.10	At the meeting of the Cabinet (a) SECRETARY - arrange for the Cabinet to consider - (i) whether the Precautionary Stage should be instituted; (ii) if so, whether decisions A.1 and A.2 or any other decisions in Part I should be authorised; (iii) whether a request from NATO Supreme Commanders to declare a Simple Alert should be approved; (iv) whether the United States and Commonwealth Governments and NATO should be informed of any decision to institute the Precautionary Stage. (b) remind the Cabinet - (v) that unobtrusive measures to improve the state of readiness of the Royal Air Force have been initiated; (vi) (vii) that the institution of the Precautionary Stage does not automatically bring into operation any further precautionary measures;	The Chiefs of Staff will be ready to make recommendations on the use of the nuclear retaliatory forces based on the United Kingdom. At an appropriate point in the meeting the Prime Minister may speak to the President of the United States, to discuss nuclear retaliation, emergency measures and the declaration of formal Alerts by NATO Supreme Commanders.

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October, 1966

UK Joint Intelligence Committee, 1967

ANNEX A TO COS 1929/2/11/67

PROBABLE NUCLEAR TARGETS IN THE UNITED KINGDOM: ASSUMPTIONS FOR PLANNING

Notes: (i) Figures in brackets denote total targets in each category; (ii) (A) denotes Air Burst; (iii) (S) denotes Surface Burst

Category	Target	Remarks	Missile Weapon yield per target	Aircraft Weapon yield per target
1. TARGETS RELATED TO ALLIED NUCLEAR STRIKE CAPABILITY (65)				
(a) CENTRES OF CONTROL ETC. (22)				
(i) Government - Central (2)	London		8 x 1 MT(A)	2 x 500 KT(A)
	Cheltenham		2 x $\frac{1}{2}$-1 MT(A)	2 x 500 KT(A)
- ex-Regional (12)	Catterick	former RSG sites; These are considered to be possible, rather than probable targets	2 x $\frac{1}{2}$-3 MT(S)	2 x 1 MT(S)
	York		"	"
	Preston		"	"
	Cambridge		"	"
	Dover		"	"
	Reading		"	"
	Salcombe		"	"
	Brecon		"	"
	Kidderminster		"	"
	Armagh		"	"
	Edinburgh	See also paragraph 2	"	"
	Nottingham		"	"
(ii) Military - Maritime (4)	Northwood (HQ, CINCHAN/CINCEASTLANT)		2 x $\frac{1}{2}$-1 MT(A)	2 x 1 MT(S)
	Plymouth (HQ, COMCENTLANT)		"	"
	Pitreavie (HQ, COMNORLANT)		"	"
	Fort Southwick (HQ, C-in-C, UK Home Station)		"	"
- Air (3)	High Wycombe (HQ, Bomber Command)		2 x $\frac{1}{2}$-3 MT(S)	2 x 1 MT(S)
	Ruislip (HQ, 3rd US Air Force)		"	"
	Bawtry (HQ, 1 Gp. Bomber Command)		"	"
(b) BOMBER BASES (including dispersal recovery and flight-refuelling bases) (32)				
(i) RAF (26)	Scampton		2 x 500 KT(A)	2 x 1 MT(S)
	Wittering		"	"
	Waddington		"	"
	Honington		"	"
	Cottesmore		"	"
	Marham		"	"
	Coningsby		"	"
	St. Mawgan		"	"
	Lossiemouth		"	"
	Macrihanish		"	"
	Leeming		"	"
	Gaydon		"	"
	Finningley		"	"
	Valley		"	"
	Bedford		"	"
	Brawdy		"	"
	Yeovilton		"	"
	Lyneham		"	"
	Wyton		"	"
	Pershore		"	"
	Boscombe Down		"	"
	Kinloss		"	"
	Manston		"	"
	Ballykelly		"	"
	Filton		"	"
	Leconfield		"	"

UK National Archives DEFE 4/224 (cf. HO 322/785)

ANNEX A TO COS 1929/2/11/67
(Continued)

			Missile Weapon yield per target	Aircraft Weapon yield per target
1. TARGETS RELATED TO ALLIED NUCLEAR STRIKE CAPABILITY (65)				
(b) BOMBER BASES (including dispersal recovery and flight-refuelling bases) (32) (Cont'd)				
(ii) USAF (6)	Alconbury		2 x 500 KT(A)	2 x 1 MT(S)
	Bentwaters		"	"
	Woodbridge		"	"
	Wethersfield		"	"
	Lakenheath		"	"
	Upper Heyford		"	"
(c) BASES ETC. FOR SEABORNE NUCLEAR STRIKE FORCES (12)				
(i) Bases (5)	Gareloch (Clyde)	Polaris	2 x 500 KT(A)	2 x 1 MT(S)
	Holy Loch	Polaris	"	"
	Rosyth (SSBN Refitting Base)	Polaris	"	"
	Portsmouth	Carrier	1 x ½-1 MT(A)	2 x 1 MT(S)
	Devonport	Carrier	"	"
(ii) Communication Installations (7)	VLF Rugby		1 x 500 KT(A)	2 x 500 KT(A)
	VLF Criggion		"	"
	VLF Anthorn (NATO)		"	"
	LF Inskip	US Navy	"	"
	LF New Waltham	US Navy	"	"
	LF Londonderry	US Navy	"	"
	LF Thurso	US Navy	"	"
2. MAJOR CITIES (20)				
	Glasgow		4 x 1 MT(A)	2 x 500 KT(A)
	Birmingham		"	"
	Liverpool		"	"
	Cardiff		2 x 1 MT(A)	"
	Manchester		"	"
	Southampton		"	"
	Leeds		"	"
	Newcastle		"	"
	Bristol		"	"
	Sheffield		"	"
	Swansea		"	"
	Hull		"	"
	Middlesbrough		"	"
	Coventry		"	"
	Wolverhampton		"	"
	Leicester		"	"
	Stoke-on-Trent		"	"
	Belfast		"	"
	Edinburgh		"	"
	Nottingham		"	"

TOP SECRET

I.R.(50) 7

29TH NOVEMBER, 1950.

MINISTRY OF DEFENCE

IMPORTS RESEARCH COMMITTEE

EXAMINATION OF PROBLEM IN PERIOD OF TENSION

Note by the Chairman.

The Chiefs of Staff recently considered+ a report by the Imports Research Committee of the Ministry of Defence on the steps that might be taken to reduce the threat of the clandestine use of atomic weapons against this country.

2. This report concluded that:

(1) the following are the most likely forms in which a clandestine attack could take place, in order of likelihood:

(a) concealing a complete atomic bomb in the hold of a merchant ship coming from a Soviet or satellite country;

(b) disguising an atomic bomb by breaking it down into a number of parts and making them up as merchandise; this could be done on any merchant ship but more easily and safely on one coming from a Soviet or satellite country;

(c) the detonation of an atomic bomb in a "suicide" aircraft flying low over a key point.

(2) there are no practicable and efficacious steps that can be taken in peace time to prepare against any of these threats.

+ C.O.S.(50) 181st: 4

TOP SECRET

11. We understand that an interdepartmental committee is considering a Ports Emergency Anchorage Scheme primarily for use in war-time in case major ports were rendered unusable by enemy action but that the dislocation it would cause to merchant shipping would be so great as to make it quite impracticable to adopt any such method of discharge in peace time, even if it were only applied to ships from a limited number of countries.

Detonation in a Civil Aircraft (Method (c))

12. Method (c) mentioned in paragraph 3 above - the use of a civil aircraft carrying an atomic bomb to be exploded at a low altitude - we do not consider so likely as the use of a merchant ship; nevertheless it is possible and there does not seem to be any answer to it. The crew of the aircraft in order to detonate the bomb at the right time would have to know what their cargo was and would therefore be a suicide squad. Short of firing on every strange civil aircraft that appears over our shores we know of no way of preventing an aircraft that sets out on such a mission from succeeding.

A Possible Deterrent

13. It follows from the above that there is a real risk of attack in the way described in our terms of reference; and that the only effective way of dealing with the most likely method of attack - namely a procedure for trans-shipping all cargoes from Soviet or satellite countries before they reach our shores - would be quite impracticable in peace time.

14. We consider however that there is a real possibility of deterring potential enemies from making an attack of this kind merely by a sufficient show of confidence that we have methods of dealing with it. Any claim to have found a scientific method of detecting an atomic bomb would be easily seen through and would be valueless as a deterrent. But a confident assurance that we know all about the problem and can deal with it might, we believe, mystify our enemy and help to dissuade him from taking so fateful a step. It may also be possible for the London Controlling Section to organise deceptive activities which, without indicating precisely how we should set about it, would support such an assertion; and we suggest that the Section should be invited to examine the problem in the light of this report.

15. The recent parliamentary questions (answered on Wednesday, 18th October) on this subject to the Minister of Defence offered an opportunity for giving the required assurance. The Minister of Defence said in his reply

> "His Majesty's Government are fully aware of this danger. It will be appreciated, however, that our assessment of the risks and the exact nature of our plans for meeting them would be of the greatest interest to a potential enemy and cannot be disclosed. We are aware of the recent action taken by the U.S. authorities and are in touch with them on the general question of defence against atomic attack".

TOP SECRET UK National Archives PREM 11/560, 12 July 1951

PRIME MINISTER

Clandestine Use of Atomic Weapons

The Chiefs of Staff have been considering the possibility that the enemy might open the next war with an atomic attack on London on the model of the Japanese attack on Pearl Harbour - without warning and before any formal declaration of hostilities. The most effective method of making such an attack would be to drop an atomic bomb from a military aircraft. If the control and reporting system were fully manned and alert in a period of tension, there would be some chance that hostile aircraft approaching this country could be intercepted and driven off. At any rate, there are no special measures, outside the normal measures of air defence, which we could take in peace-time to guard against this type of attack.

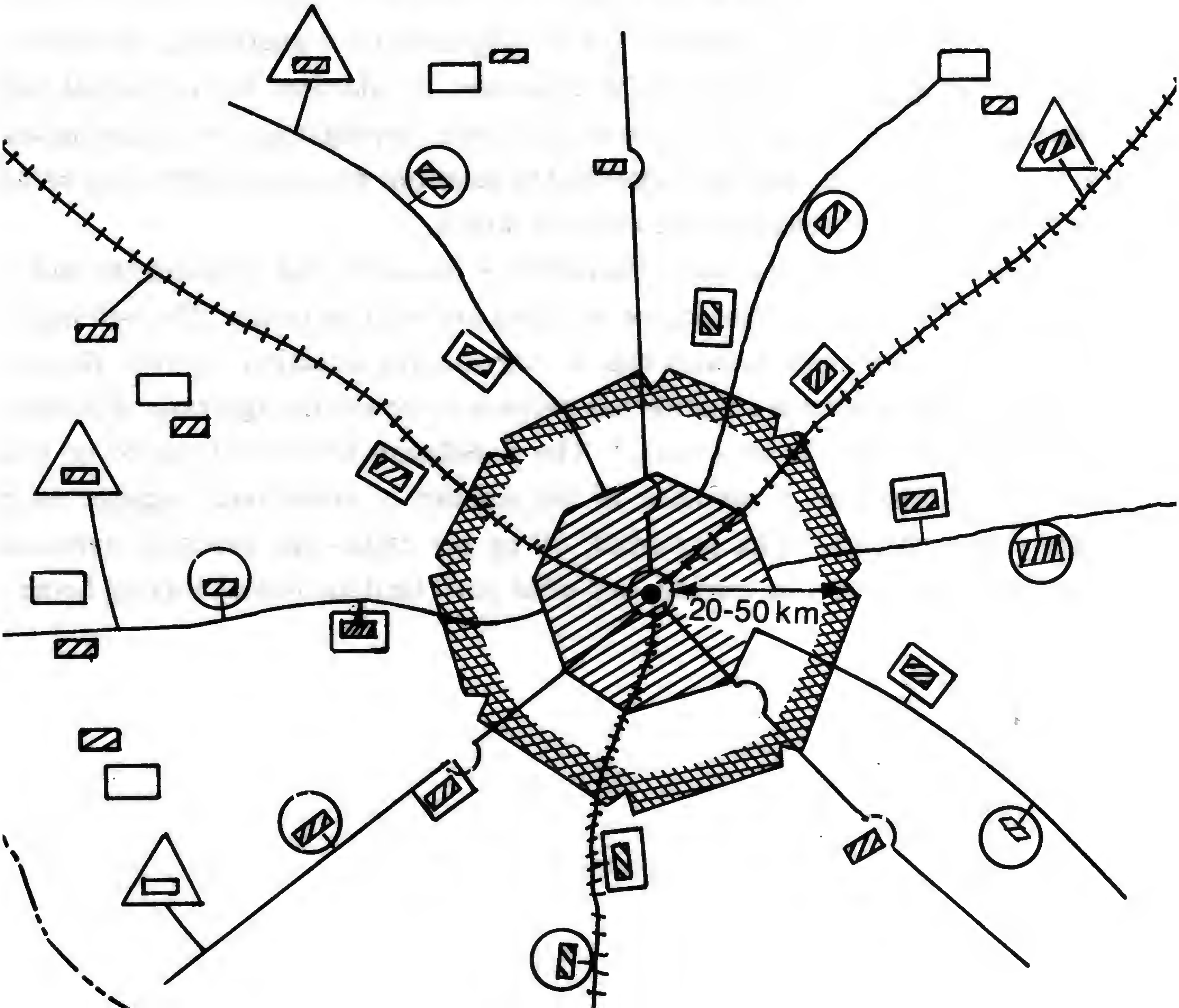
2. It is, however, possible that the enemy might use other means of surprise attack with atomic weapons. A clandestine attack could be made in either of the following ways:-

(i) A complete atomic bomb could be concealed in the hold of a merchant ship coming from the Soviet Union or a satellite country to a port in the United Kingdom:

(ii) An atomic bomb might be broken down into a number of parts and introduced into this country in about fifty small packages of moderate weight. None of these packages could be detected by instruments as containing anything dangerous or explosive, and even visual inspection of the contents of the packages would not make identification certain. These packages could be introduced either as ordinary merchandise from Soviet ships, or possibly as diplomatic freight. The bomb could subsequently be assembled in any premises with the sort of equipment usual in a small garage, provided that a small team of skilled fitters was available to do the job.

Civil defense youth training

CHART 4—Schematic Diagram of the Relocation of Dispersed Workers and Evacuated Persons and Plants.



FOR EXTERNAL PUBLICATION

Radio Moscow in Mandarin to China, Nov. 3, 1978.

"However, the fact is that China's digging deep tunnels can never protect the Chinese masses from nuclear bombing or even protect them from conventional heavy bombs."

* * * * * * * * * *

Radio Moscow World Service in English, Nov. 16, 1978

"The U.S. Administration is going to launch a 5-year program of civil defense. - - - The only real safety for the Americans is strengthening friendship with the Soviet Union, not bomb shelters."

FOR INTERNAL PUBLICATION

Moscow *Voyennyye Znaniya* in Russian No. 5, May 1978, p. 33.

"It is appropriate to say that we still meet people who have an incorrect idea about defense possibilities. The significant increase in the devastating force of nuclear weapons compared with conventional means of attack makes some people feel that death is inevitable for all who are in the strike area. However, there is not and can never be a weapon from which there is no defense. With knowledge and the skillful use of contemporary procedures, each person can not only preserve his own life but can also actively work at his enterprise or institution. The only person who suffers is the one who neglects his civil defense studies."

UK EYES A

TOP SECRET

Possibly of general interest. Circulate in Private Office (no flows): then enter r.p.a. [illegible] 21/2

NOTE OF A CONVERSATION BETWEEN THE PRIME MINISTER AND THE SECRETARY OF STATE FOR DEFENCE AT 10 DOWNING STREET ON 20 FEBRUARY 1978

(The Prime Minister had asked the Defence Secretary to call on him to discuss the paper by the Chiefs of Staff, forwarded to the Prime Minister under cover of Mr. Mulley's minute of 16 January, on "Response to the Soviet Threat to Targets in the UK".)

The Prime Minister said that he would like to have a clearer idea of how the NATO defence system actually went into operation. He had noted, for example, that according to the Chiefs of Staff paper, 200 Soviet bombers would be confronted by only 100 UK fighters with sufficient ammunition for only two to three days' operations. Against this background, what would be the sequence of events if the Soviet Union did in fact try to knock out the UK first before taking on the rest of NATO? How would the collective NATO response manifest itself? Mr. Mulley said that in this situation General Haig would divert aircraft which were deployed on the Continent. The new Soviet "Backfire" bomber was the main problem. The Prime Minister asked whether there was a definite NATO contingency plan on how the Alliance would respond in the situation which he had outlined. Mr. Mulley said that there was no plan to transfer NATO aircraft to stations in the UK; but in practice American aircraft would be diverted from other operations.

The Prime Minister asked Mr. Mulley whether this lack of certainty and definition did not cause him concern? Mr. Mulley replied that in his view it all went back to the 1965 Defence Review, which had been crazy. The RAF, for example, was suffering from an acute manpower shortage. The new air defence version of the Tornado aircraft would not come into operation until 1985 (the FRG and Italy were ordering only the strike version, which would be available earlier).

/The Prime Minister

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The Prime Minister asked Mr. Mulley about the general expectation of the probable nature of the next war. Mr. Mulley said that any Soviet attack would probably follow a period of tension; it would not come out of the blue. It might result from situations such as had arisen in the past in East Germany and Czechoslovakia. Ultimately, responsibility within the Alliance for knocking out the Russian nuclear capacity lay with the United States. The Prime Minister asked whether Mr. Mulley therefore saw no prospect of a semi-conventional war, involving tactical nuclear weapons, but nothing larger; and with a major role for conventional, rather than nuclear, aerial bombardment. He asked where the Soviet Union's tactical weapons were sited. Mr. Mulley said that they were mostly in the Western Soviet Union. The Prime Minister asked whether the Soviet Union had an equivalent to the Jaguar aircraft. Mr. Mulley said that the Russians did have an equivalent, mostly stationed in the GDR. Mr. Mulley went on to say that the Soviet Union had just introduced the new SS20 missile, whose natural targets were France and the FRG. This was a highly mobile missile which made it difficult to knock out.

The Prime Minister asked whether he should conclude from Mr. Mulley's remarks that he had been talking about a scenario which was not in fact likely to happen. Mr. Mulley confirmed this. The Prime Minister asked whether UK Phantom and Lightning fighters were capable of taking on the Soviet Backfire bomber. Mr. Mulley said that they were. The Backfire bombers, however, would probably fly very low en route to the UK, thereby beating our radar warning systems. Against this, we were improving our radar coverage through the Nimrod flying radar system; and we were also developing the capacity to refuel fighter aircraft in the air. The Nimrods would be in operation by 1982.

The Prime Minister asked what would happen when a Nimrod detected a Backfire attack. Mr. Mulley said that the first step would be to send up Phantom fighters to intercept them. But they were short of ammunition and could operate, as the paper pointed out, for only two to three days. The Prime Minister asked why we were in this situation; it seemed to him a scandal. Mr. Mulley agreed and said that in his view the Phantoms should have ammunition for at least six days' operation.

/The Prime Minister

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Prime Minister
You asked for this assessment.
[initials] 17/1

Thank you
I would like to
talk to Mr Mulley
about this
28/1

PRIME MINISTER

DEFENCE AGAINST THE SOVIET THREAT TO THE UNITED KINGDOM

When you read the paper JIC(77)10 about the direct Soviet threat to the United Kingdom you asked what capability we had to meet it. I attach, as requested, a note by the Chiefs of Staff.

2. To get matters into perspective one must recognise that our main protection comes from collective overall deterrence. Even the United States relies on this. The Soviet Union faces an Alliance, not the UK in isolation; and it faces moreover a military capability running right up to the strategic nuclear level.

3. Nevertheless, the picture the Chiefs of Staff set out is a sobering one. Britain is a far nearer and more concentrated target than the US and is the hinge of the Alliance's response to any major aggression. It ought not to be left easily open to conventional attack, and its direct protection is indeed one of the four main "concentration" areas of our defence effort; yet the note shows that our current capability to protect it is uncomfortably thin. I do not think our posture reflects any seriously mistaken assessment of defence priorities, but we should be aware of the realities of our position. I intend to consider with the Chiefs of Staff whether

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there is anything more we can do, within current resources and priorities, to improve it.

4. I am sending copies to our colleagues on DOP and to Sir John Hunt.

FM.

16th January 1978

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RESPONSE TO THE SOVIET THREAT TO TARGETS IN THE UK

PART I - SUMMARY

1. The Soviet conventional threat to the UK and its approaches embraces attack from the air by aircraft with free fall or stand-off weapons, and submarine launched cruise missiles; submarine and mining activity against NATO shipping and sea-borne reinforcements; and clandestine and Warsaw Pact Special Force operations on land. The nuclear threat is from ballistic missiles and from aircraft using free-fall bombs and stand-off missiles. There is also a chemical threat.

2. Defence of the UK against Soviet aggression would form part of a cohesive effort by the NATO alliance which recognises that aggression against one member constitutes an attack on the alliance as a whole. The effectiveness of our defences is critically dependent on NATO collectively making the maximum use of available warning time to bring in-place forces to full readiness and begin the process of reinforcement.

3. NATO strategy is one of deterrence and flexible response which does not necessarily require us to have a capacity for successful defence at every level. However, there is a need for a credible conventional capability to respond appropriately or deterrence is weakened, and the need for early recourse to nuclear weapons has to be faced.

4. Because of limitations in defence expenditure over a long period, front-line and logistic elements are frequently concentrated by function and in unhardened positions. Command and control facilities are also largely unhardened. Although some geographical dispersal would occur on transition to war, defence facilities in the UK are vulnerable.

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ANNEX TO
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16th JANUARY 1978
Continued

5. UK forces cannot match the threat postulated by the JIC assessment (1). Air defences would be outweighed because aircraft would be outnumbered and stocks of air defence munitions would sustain operations for only two or three days. Maritime forces need better anti-submarine weapons, and face a massive threat from submarine and air-launched missiles and also from mines; the most serious deficiency is in numbers. The Army in UK would, until mobilisation is complete, have insufficient forces to meet its commitments; after mobilisation of the reserves, a process taking between 15-20 days (mobilisation to mainland Europe takes 10 days), the Army would be able to counter the currently assessed Soviet land threat during the initial stages of war but, lacking supporting arms and logistic support, it would be inadequate to deal with any more significant threat, including sabotage or subversion on a wide scale.

6. In the case of nuclear attack by ballistic missiles there would be no defensive capability, save the indirect defence of our nuclear forces. Effective air defence against aircraft-launched nuclear weapons would also be extremely difficult. However, the main focus would by then have moved to the use of our own strategic and tactical nuclear resources.

7. Defence against chemical attack is limited largely to personal protective measures for a proportion of Servicemen.

8. Improvements presently planned will enhance the quality of UK defences but Soviet forces will also be improved in quality as well as quantity over the same period. As a result, UK defences are likely to be as thin in the future as they are now; and, if present

Note:

1. JIC(77) 10 dated 24 October 1977.

divergent trends in Soviet and UK defence capability continue, the situation could only deteriorate further.

9. Given even the maximum use of warning time, it is unlikely that the UK defences could prevent the loss of a substantial proportion of NATO's forces based in the UK, including important US assets, which would significantly reduce NATO's ability to sustain conventional operations successfully in Europe, in the Eastern Atlantic and in the Channel Areas.

ANNEX TO
MO 15/3 DATED
16th JANUARY 1978
Continued

PART II - MAIN ASSESSMENT

RESPONSE TO THE SOVIET THREAT TO TARGETS IN THE UK

BACKGROUND

1. A recent JIC Report (1) assessed the Soviet capability to attack targets in the UK as part of general aggression against NATO when the Soviet Union had completed full war preparations. The Prime Minister subsequently called (2) for an assessment of how UK/NATO forces would defend UK targets against the assessed threat.

AIM

2. To assess the capacity to defend targets in the UK Base against the Soviet threat. Civil defence is not considered.

GENERAL STRATEGY

3. Our principal military safeguard lies in NATO's collective capability to deter aggression of all kinds, by making it clear that an aggressor would be involved in disproportionate risks. Deterrence does not require a capacity for successful, self-contained direct defence at every level but rather the ability to respond in an appropriate manner to any form of aggression and convey the threat of escalation to a higher level. The UK, as an independent nuclear power and host nation to large and powerful US forces, would pose a serious problem to the Soviet Union if it were contemplating an attack.

4. Deterrence and defence is based on the NATO Treaty provision that aggression against one member constitutes an attack on the alliance as a whole. However, defence of the UK base, Eastern Atlantic and Channel Areas is largely a British responsibility.

Notes:

1. JIC(77)10 dated 24 October 1977
2. Letter from 10 Downing Street dated 21 November 1977.

Moreover, the UK is crucial to NATO strategy as a marshalling and transit area for transatlantic reinforcements, a base for maritime forces controlling the Eastern Atlantic and keeping open the shipping lanes, and as a base for SACEUR's operations. The loss of a substantial proportion of NATO's forces based in the UK would significantly reduce NATO's ability to sustain conventional operations successfully in Europe, the Eastern Atlantic and the Channel Areas, and thus increase the risk of the need to resort to early use of nuclear weapons.

DEFENCE AGAINST CONVENTIONAL THREAT

The Conventional Threat

5. The most immediate Soviet conventional threat is from heavy and medium bombers, and long range tactical aircraft (which have many times the capacity, accuracy and effectiveness of the Germans at their peak in World War II). Also serious is the threat against shipping and shore targets from attack/cruise missile submarines, and the mining of ports and sea approaches, clandestinely or by air. At an early stage clandestine operations within UK might be mounted by the Diversionary Brigade Special Forces and by saboteurs.

6. Likely targets for Soviet attack on the UK base in conventional war are assessed (1) as:

a. All nuclear strike forces and nuclear delivery systems.

b. Other facilities, including command and control installations, associated with British and American nuclear forces.

c. Air defence facilities.

d. Maritime forces and reinforcements being moved to and from the UK.

Note:

1. JIC(77)10 dated 24 October 1977.

In addition there would be the conventional offensive support forces based in UK and reinforcements moving to and from this country by air.

General Concept of Operations

7. The effectiveness of NATO's defences depends critically on NATO nations collectively making best use of available warning time to bring in-place forces to full readiness and to initiate reinforcement. UK defence resources would be dispersed as much as possible during the transition to war phase but would still be vulnerable because the options for deployment have been reduced as a result of defence cuts over some years. Unavoidable concentration of front-line and logistic resources by function, and the fact that command and control facilities are largely unhardened, contribute to the degree of vulnerability. In subsequent paragraphs we examine how our forces, in concert with those of our allies, would meet the conventional threat in the initial stages.

Countering the Air Threat

8. By virtue of its geographical position, the UK would benefit from any attrition that other NATO forces might inflict on Soviet air forces en route to attack targets in the UK, but a substantial weight of attack directed at the UK is likely to remain. If Soviet land forces made a major advance large numbers of fighter bombers could also be deployed within range of UK.

9. Against a threat of more than 200 Soviet bombers we have a front-line strength of less than 100 fighters together with very limited area coverage of surface-to-air missiles. Although the fighters could acquit themselves well, they have sufficient missiles for only two to three days operations. The numbers of surface-to-air missiles in the UK and afloat are also inadequate; there are only enough Bloodhounds, which cover 15 key RAF and US airfields,

for a single reload. Air defence relies upon a largely unhardened radar ground environment, supplemented by information from continental radars and a single squadron of obsolete airborne early warning aircraft. Much of the command and control system is unhardened, insecure and vulnerable to sabotage and jamming. As yet there are no hardened shelters for aircraft, although the USAF have started to provide this protection for their aircraft in the UK. It is evident that concentration of the Soviet air effort in space and time would be difficult to contain.

10. Improvements in UK air defence capability are planned, but Shackleton AEW will not be replaced by Nimrod, and the Lightnings and Phantoms by Tornado, until the mid 1980s. Stocks of air-to-air missiles will not be built up until 1983, and improved ground environment and hardened shelters for our fighters will not be available until later. However, by this time it must be expected that the Soviet capability will have developed further both in quality and quantity, so that the overall position cannot be expected to improve.

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Countering the Maritime Threat

11. The forces with which the Royal Navy and Royal Air Force would counter the initial threat would be largely, but not exclusively, anti-submarine. They would operate in concert with allied forces. In general, as far as quality is concerned, UK forces are well equipped to meet this threat although anti-submarine operations in the shallow waters surrounding UK would be difficult and there is a need for better anti-submarine weapons. But even taking into account allied resources, our most serious deficiency is in numbers. Our maritime resources would be spread very thinly in the Eastern Atlantic Areas and the threat they would face is

massive. The amount we could afford to assign to submarines directly threatening the UK base would be limited. Overall we could expect to destroy only a proportion of the submarines which threaten us. There are no port or coastal defences against cruise missile attacks and much would also depend on the time available to send ships to sea before they are attacked in port.

12. It is a national responsibility to deal with Soviet mining of ports and approaches but national resources fail to match the assessed threat. The Royal Navy's mine countermeasures vessels would have as their first priority keeping open the approaches to the nuclear submarine base at Faslane; after this, insufficient resources would remain to deal adequately with the tasks of clearing cross channel routes and providing safe access to our major ports.

13. There is a constant programme of improvements planned for UK maritime forces which will enable us better to match the threat, but even if sufficient resources were made available it would be some years before the present deficiencies could be made good. For the present, economic constraints, which limit expenditure on training resources such as missiles and aircraft, adversely affect readiness and hence the deterrent effect of alliance maritime forces.

Countering the Land Threat

14. Land operations in the UK would be based on the provision of guards for essential Key Points installations, which are possible targets for Soviet attack by Diversionary Brigade Special Forces and by saboteurs. Armed guards would be provided by all three Services but predominantly by the Army. The requirement for guards on Key Points before mobilisation would greatly exceed the forces available. During mobilisation,

manpower commitments would increase and continue to outnumber the Regular and TAVR forces available. It would be only when the Reserve Army was fully effective, some 15-20 days after mobilisation, that the Key Point commitment could be fully met. Yet the sabotage threat is at its greatest immediately before, or at the outbreak of, hostilities for which we may receive as little as 48 hours warning. A call-out of reservists as early as possible would ease the situation. It would be several days after mobilisation before some Regular and TAVR units would be released from guarding Key Points to deal with the unforeseen. Moreover, Home Defence forces are mainly infantry battalions at light scales, only partially mobile, and equipped to deal with a threat posed by groups of Diversionary Brigades Special Forces and by saboteurs. They lack the supporting artillery, armour, communications and logistic support needed for operations against larger seaborne or airborne forces, whose use by the Soviet Union is not excluded during the latter stages of hostilities.

DEFENCE AGAINST NUCLEAR AND CHEMICAL THREAT

The Nuclear and Chemical Threat

15. It is assessed (1) that the Soviet Union might have available for an attack against the UK up to 150 land-based strategic nuclear missiles, each with a single warhead, and about 160 medium bombers. About 130 submarine-launched ballistic nuclear missile are available for attack on NATO Europe, of which a proportion would be targetted on the UK. By 1982 Soviet land-based missiles will be capable of attacking up to 200 targets, and the number of available medium bombers will

Note:

1. JIC(77)10 dated 24 October 1977.

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increase to nearly 200. The likely targets are assessed (1) as being:

a. Allied nuclear strike capability, including associated facilities.

b. Centres of political administration and major cities.

c. Command and control and air defence centres, radars, and airfields, and seabed surveillance systems.

d. Naval bases, ports and facilities associated with the movement of reinforcements.

16. The JIC paper mentions the considerable capacity of the Soviet Union for mounting chemical warfare and warns that it would be imprudent to ignore the possibility of such an attack on the UK. Present defence is limited. Although most servicemen possess respirators only some have protective suits. Steps are in hand to increase the number of suits on a limited scale. Airfields in the UK are not hardened against chemical attack and only a few headquarters have any built-in protection.

Nuclear Strike

17. The UK has no defensive capability against nuclear ballistic missile attack save the indirect defence of a nuclear response. Resources would as far as possible be dispersed on transition to war and the Ballistic Missile Early Warning System (if it had survived the conventional phase) would provide short but sufficient warning of a ballistic missile attack to enable aircraft to take off for survival or retaliatory strike.

18. Attrition during a conventional phase would reduce the air defence resources available to face an attack by aircraft carrying nuclear weapons. Such effort as survived would face the difficulties of operating from a radiation-contaminated environment against an

Note:

1. JIC(77)10 dated 24 October 1977.

enemy who could use powerful nuclear stand-off weapons launched at up to 350 nautical miles from their targets. In these circumstances it would be very difficult to sustain effective air defence.

IMPLICATIONS

19. The implications of this assessment are:

a. If deterrence failed, the defence of the UK would be critically dependent upon NATO making the maximum use of available warning time to bring all forces to full readiness and to begin reinforcement prior to war.

b. Given even the maximum readiness of NATO forces, it is doubtful if the defences of the UK would be sufficient, even against only conventional attack, to prevent vital elements of NATO's military capability being substantially damaged or destroyed.

c. The early loss of substantial NATO forces based in or transitting through the UK could force rapid escalation to the nuclear level and greatly reduce the time available for political resolution of the conflict.

20. The weaknesses described above will remain throughout the period covered by the JIC assessment. If present trends in Soviet and NATO capability continue, the gap will widen between the forces available to attack the UK and our ability to defend effectively against them.

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The Future of Non-Strategic Nuclear Forces

Are These Capabilities Still Needed? (U)

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The Future Of Non-Strategic Nuclear Forces

Are These Capabilities Still Needed? (U)

Joseph S. Howard II

Edward I. Whitted

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The Future Of Non-Strategic Nuclear Forces

Are These Capabilities Still Needed? (U)

by

Joseph S. Howard II
Edward I. Whitted

ABSTRACT (U)

The epochal political events of 1989–1990 are greatly influencing US non-strategic nuclear forces (NSNF). NATO NSNF strategy is undergoing revision. The London Communique of July 6, 1990 is the harbinger of an intense debate upon future NATO nuclear roles and missions. The President's cancellation of the Follow-on-to-Lance missile (FOTL) and the offer of withdrawal of forward-deployed nuclear cannon projectiles to NATO indicate downward trends in future NSNF stockpiles.

This report, in the form of an executive summary and an annotated briefing, presents the results of a yearlong policy and systems analysis investigation. The authors examine plausible rationale, first principles, that govern the justification for future NSNF. They then assess the capabilities of reduced stockpiles during 1995–2000 wherein regional powers may possess nuclear arms. By configuring three nuclear scenarios in which US vital interests are at stake, the authors analyze the number of NSNF weapons to investigate "how much NSNF is enough?" They also examine implications to the US Army should downward trends in short-range nuclear forces continue.

EXECUTIVE SUMMARY

<u>Background</u>

The world has witnessed such revolutionary changes over the past 18 months that clearly a new era has started. In this context, the authors undertook a study in late 1989 with partial Army support that would assess future European short-range nuclear force (SNF) structures and target sets. The rapidity of the political changes in Europe and the Soviet Union at the early stages of the effort motivated broadening the study to include strike non-strategic nuclear forces (NSNF) in a worldwide context. Also, the nature of the evolving era indicated that a traditional target-based analysis would be sadly deficient without underlying policy and economic assessments. These assessments have led us to conclude that, even more than before, future stockpiles will not be determined strictly on the basis of threat target defeat. Stockpiles will be configured from a complex interaction of domestic and international politics, defense budgets, arms control treaties, and differing threat perceptions.

The events in Europe are also affecting US NSNF strategies for other theaters. The outcome of future Nuclear Weapons Requirements Studies (NWRS) from the nuclear CINCs may profoundly affect NSNF roles and missions of the services. Trends in late 1990 were moving toward a denuclearization of the Army in the sense that organic nuclear systems might be retired.

Therefore, this paper examines the 1995-2000 rationale, roles, and capabilities of US NSNF in light of the revolutionary changes in Europe, plausible future nuclear threats worldwide, and downward trends in NSNF due to economic and political pressures.

<u>Policy Findings: Strong Reasons for NSNF</u>

The strategy and policy reassessment of US NSNF identified strong rationale for a continued role:

• As a visible instrument of superpower status in an uncertain and unpredictable world

• As a deterrent to future non-superpower nuclear-capable adversaries in a proliferated world

• As a deterrent to regional Soviet or Russian aggression as long as resurgence or reconstitution remains feasible

• To provide stability and insurance in a post-CFE Europe through a small air-delivered, forward-deployed force

Because of European politics, US NSNF structure decisions must be broader than peacetime NATO strategies, policies, and constraints.

The old *raison d'etre* for US NSNF: the Soviet Threat

1. **Democracies and economies of Western Europe**
2. **The overriding threat: the Soviet Union**
3. **NATO was unable to provide sufficient conventional forces**
4. **Deployment of nuclear weapons to Europe created an extended deterrence umbrella for conventional force deficiencies**

Other US CINCs were also allocated NSNF for deterrence of the worldwide Soviet Threat

Initially behind the deployment of US forward-based nuclear forces has been the threat of Soviet landpower, and subsequently the Soviets' own theater nuclear capabilities. The victory of the allies in the Second World War led to several unforeseen events: one was the raising of the Iron Curtain in the late 1940s through the subjection of Eastern European countries by the Soviet Union. The US, after fighting a war against totalitarianism, turned to a grand strategy of containment of Soviet imperialism. A free and prosperous Western Europe continued to be of utmost interest to the US; and therefore, the NATO alliance was formed to draw the line against further Soviet expansion. Unfortunately, the Soviet Union and its Warsaw Treaty Organization (WTO) alliance deployed forces far beyond those required for its own defense. Unable and unwilling to match the conventional force goals of the 1952 Lisbon Conference, the US deployed its first theater nuclear weapons for NATO in 1953.

Over the past 45 years, NATO nuclear doctrine has evolved from "massive retaliation" in MC 14/2, to "flexible response" in MC 14/3, then to the development of provisional political guidance (PPG) for initial and follow-on nuclear use, next to the Montebello modernization decisions, and now to the proposed "weapons of last resort" from last summer's London communique. But behind all of these declaratory doctrines and revisions, excepting the last, has been the massive Soviet threat.

The US strategy of extended deterrence, operative with the forward-deployment of US weapons and nuclear guarantees to the allies, has created a tension between the Europeans and the US. The presence of US weapons in Europe has been emphasized by the Europeans as a coupling to the US Central Strategic Forces. Hence, the specter of Armageddon must always reside in the calculus of the Soviet Union. Conversely to the US, the presence of theater nuclear weapons (now NSNF) gave an aura of credible response options before the ultimate response.

The presence of NSNF in Europe contributed to the long peace of 45 years

These weapons helped to deter the Soviet Union from initiating nuclear coercion or overt aggression against the NATO alliance

This occurred in spite of, or perhaps because of:

Ambiguities in NATO declaratory policies such as Flexible Response

Difficulties in developing battlefield nuclear weapon doctrine and concepts

Questions in survivability of NATO main operating bases

Unclear or unfavorable results from NATO nuclear exercises and war games.

The sheer destructive power of NSNF made the cost of a general European war too high, too uncertain about the prospect of victory, Pyrrhic or otherwise. NSNF engendered cautious behavior.

We argue that the existence of theater nuclear weapons was a major factor for the past 45-year peace in Europe. Prior to the stabilizing effects of NATO, due in part to its nuclear weapons, the European continent had been the scene of several major wars and periods of crises, largely stemming from rampant nationalism. The bipolar Cold War stabilized Europe, and the mass destruction available from nuclear weapons made a European general war too horrible. The evidence of NSNF contributing to the long peace of the past 45 years is persuasive:

- The Soviets in their own writings admit to unfavorable "correlation of force ratios" when NATO nuclear weapons are factored in.

- The danger of NATO nuclear use is clearly evident in their doctrine and training exercises. Dispersion of their forces is a norm prior to quick massing at the point of decisiveness.

- The Soviets undertook their own huge development and deployment program to field theater weapons for every practical delivery means.

The strategies of NATO worked. They worked in spite of ambiguities in NATO declaratory policies; ambiguities necessitated by political constraints and public acceptability. A number of employment questions and apparent deficiencies arose over the years as witnessed by changes in NATO doctrine (MC 14/2 to MC 14/3), results from exercises, and in recurring debates on NATO modernization such as the two-track decision.

But it all worked to keep the peace. The US policy of extended deterrence within NATO's nuclear declaratory and operational strategies made the cost of aggression too high to Soviet leaders. These weapons engendered cautious behavior. The costs of a general war became much too high.

But Future Regional Threats dictate three NSNF Deterrent Rationales broader than European stability forces

War prevention and war termination where US vital interests are involved:

2. A visible symbol of national power in an uncertain & unpredictable multipolar world

3. A deterrent to future non-superpower nuclear–capable adversaries in a proliferated world

4. A deterrent to regional Soviet or Russian aggression as long as resurgence or reconstitution remains feasible.

NSNF Roles

- **An incalculable risk to the threat(s)**
- **Appropriate & credible non-strategic nuclear options including capabilities for in-kind nuclear response**
- **Direct defense of endangered US forces**

The first major rationale for NSNF derives from its contribution as a political instrument and an insurance policy for the superpower US Although not often on center stage in a number of regional disputes or conflicts, NSNF availability in the wings has certainly played an important role in diplomatic interchanges and crises.

A future nuclear-proliferated world would present enormous challenges to US defense interests. Over ten nations possess the capabilities to obtain nuclear armaments in the next decade. Several of these nations maintain profoundly hostile relations to the US As regional powers in their own right with significant conventional armaments, their addition of nuclear capability would raise grave risks to deployed US forces.

While the aggressive intentions of the Soviet Union towards Europe may have disappeared, their conventional and nuclear capabilities remain huge. While the short-warning scenarios are no longer credible, a future resurgent and mobilized Soviet Union remains feasible. While intentions can move towards amicability, they can subsequently be reversed upon change in leadership. The Soviet Union or the greater Russian Republic, should some republics become autonomous, may have future cause to counter US vital interests in critical regions such as Southwest Asia, despite present trusts.

Therefore, we are incredulous of US forces without NSNF to prevent war or to terminate war against hostile nuclear-armed states. The rationale for NSNF must rest upon its capabilities to deter a plausible resurgent Soviet Union, or any of several regional powers with potential nuclear capabilities. As NSNF kept the long peace in Europe because it engendered cautious behavior, so should NSNF be kept as an incalculable risk towards any nuclear state contemplating aggression.

The rationale for NSNF also involves the element of credibility: the NCA should have options other than central strategic forces for an appropriate response.

US NSNF structure issues and decisions should be broader than peacetime NATO strategies and policies

European political imperatives unsupportive of NATO NSNF modernization (except for safety and security enhancements to air-delivered weapons)

↓

NSNF rationales support some US nuclear capabilities kept up-to-date

↓

CONUS- based NSNF, subject to US political and budgetary constraints, can then be streamlined to meet broader US NSNF military requirements

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This study points to an expansion of the US rationale for having NSNF. Their *raison d'etre* has been to deter the massive Soviet threat to Western Europe. Now that this threat has been discounted by most policymakers, reasons for continued NSNF capabilities should be publicized. The US ought to forward deploy a relatively small stockpile of air-delivered munitions and DCAs as a hedge against uncertainty, but modernization for NATO likely will be foreclosed except for safety and security enhancements.

The rationales as a superpower instrument, to deter a resurgent Soviet Union, and to deter future nuclear capable regional powers in contingency operations require up-to-date NSNF capabilities. US decisions on force structures and issues must be broadened beyond the narrow confines of NATO acceptability to include worldwide US requirements. Decisions upon the character and composition of future CONUS-based NSNF will be subject to severe domestic political and budgetary constraints as is. NSNF ought not to be held captive to European concerns especially when they are not to be forward-deployed except in crises.

Rationale Findings

1. NSNF should remain a key element within US defense strategy
2. Rationale for existence is for broad worldwide contingencies
   - Visible instrument of national power in a multipolar world
   - Deterrence of future regional adversaries with nuclear capabilities
   - Deterrence of reconstituted Soviet theater threats
   - Forward-deployed force for stability in Europe
3. US NSNF structure issues and decisions should be broader than peacetime NATO strategies and policies
4. Reductions in strategic forces may strengthen rationale for NSNF

NSNF, in summary, should continue in its important role towards keeping the peace. Their rationale must broaden from a NATO *raison d'etre*, where a small force furnishes stability and insurance in Europe, to worldwide contingencies. These include the deterrence of a reconstituted Soviet Union and of future nuclear-capable regional threats. As a superpower, the US ought to maintain NSNF as a visible symbol in our relations within a multipolar world. Therefore, US NSNF structure issues and decisions should be made in the broad context of worldwide US strategies and policies. Reductions in strategic forces might strengthen the rationale for non-strategic nuclear systems.

Credible deterrence

necessitates *will* to employ nuclear weapons as

expressed in declaratory strategies and roles,

and effective military *capability*

Capability is assessed in this study by analyzing the effectiveness of arms control-restricted, policy-driven, and budgetary-constrained stockpiles against reduced target sets

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An axiom – the degree of nuclear deterrence relates directly to will and to capability. Declaratory strategies and roles ought to express national will in explicit terms that will deter potential adversaries. Capability ought to be visible, perceived as effective, and trained with in peacetime to ensure that no doubts are raised concerning its credibility during crises or armed conflicts.

For the post-Cold War era, the target sets reflect substantial reductions in type and numbers. The availability of two systems, the Air Force SRAM T and the Army W79 for the 8-in. howitzer, is questionable in light of ongoing arms control, policy, and budgetary debates. The capabilities analyses that follow incorporate these considerations.

Based upon IC projections we assumed an upper bound of three future regional threats to analyze NSNF stockpiles

1. Reconstituted Soviet Union or greater Russian Federation

DELETED

DOE 6.2(a)

- *Casus belli*: nuclear coercion; imperialistic; survival; or economic
- Reentry into Eastern Europe; invasion into SW Asia/ Middle East

2. Pacific basin, regional nuclear adversary, e.g., North Korea

DELETED

DOE DoD 6.2(a)

- *Casus belli*: nuclear coercion; invasion of South Korea

3. Middle East, regional nuclear adversary, e.g., federation of Iran and Iraq

DELETED

DOE DoD 6.2(a)

- *Casus belli*: nuclear coercion; control of oil supplies; Arab federation to destroy Israel.

DELETED

DoD 6.2(a)

Let us assume that the US would want to maintain an NSNF force for the rationale presented in Section II. This force should be configured to fulfill missions against a resurgent Soviet Union (or greater Russian federation) and against previously unnamed regional powers with incipient nuclear delivery means. Because the US has traditionally maintained conventional forces to fight in two directions -- across the Atlantic to Europe and towards the Middle East/Southwest Asia, and across the Pacific to the Far East --, we assume that future grand strategy will include the forces to undertake two contingency operations at the same time. And for insurance, the force should preserve the wherewithal in conventional and nuclear means to deter a reconstituted Soviet Union that might assist these regional powers.

Undoubtedly a reconstituted Soviet Union would drive US NSNF stockpile numbers (in addition to the forward-deployed nuclear weapons for peacetime stability in Europe). Their capabilities in NSNF remain almost awesome despite changing intentions and decreases in production of armaments. It is not necessary for our purposes to spell out the road to crisis or to war. It might be a future combination of nuclear coercion, renewed interest in East European domination, oil proclivities towards the Middle East, or others.

From lists of states that might have nuclear weapons and delivery platforms in the next ten years or so, we selected three states with intense animosities towards the US: North Korea, and a federation of Iraq and Iran. In the former case, the *casus belli* might be the reunification of the Korean peninsula under North Korean control. In the latter, the *casus belli* might be oil control, or a holy war to exterminate Israel. For either regional contingency, the opposing threat nuclear weapons would number less than a hundred.

EXHIBIT 5

AN INTRODUCTION TO DISASTER PSYCHOLOGY

USNRDL Reviews and Lectures No. 4, September 8, 1955, by W. E. Strope

MILITARY EVALUATIONS GROUP

UNITED STATES NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO, CALIF.

AN INTRODUCTION TO DISASTER PSYCHOLOGY [1]

By Walmer E. Strope [2]

In 1917 an ammunition ship blew up in the harbor of Halifax, Nova Scotia. The ship contained 3,000 tons of TNT. In the terminology of the atomic era, this would be called a 3-kt detonation. Of course, it was a conventional explosion with none of the radiological implications of atomic attack.

Nonetheless, the blast was devastating to the port city of Halifax. The northern part of the city was destroyed, more than 1,800 people were killed, approximately 20,000 others were injured, and many more thousands were rendered homeless in the dead of winter.

There were several official reports of inquiries into the causes and effects of the Halifax explosion. Sociologists and other scholars also studied various aspects of the disaster. These reports are united upon one fact. They each note with some surprise the magnificent performance of a small group of people, who were among the heroes of the Halifax disaster.

This group of people quickly went to the aid of the survivors, organizing the first relief station at Halifax. This was in operation by noon of the day of the disaster. Who were these people? And why was their heroism thought to be unusual?

They were a company of traveling actors who were performing at the local opera house at the time of the explosion. In 1917, the acting profession was not considered to be a particularly useful and acceptable part of society. Actors were generally held to be rather peculiar, somewhat irresponsible, and thoroughly self-seeking. Why, then, did a troup of actors becomes heroes when a major disaster visited the city? At the time, no one know.

PEOPLE ARE MOMENTARILY STUNNED BY AN UNSTRUCTURED SITUATION

People at Texas City, for example, spoke of being frozen into momentary immobility, of not knowing what had happened, or what to do next. A study [3] of the Texas City disaster reaches the following conclusions: "The shattering of normal expectations by an unexpected even presents the individual with an unstructured, undefined situation in which he does not know what to do." The shock reaction at Halifax has been described [4] as "being suddenly stricken with blindness and paralysis." Some of this sensation of disability and helplessness may be due to physical forces such as blast concussion and the like, but the effect of "stun" is also seen in people who are no subjected to any physical force. It is therefore more probable that it is purely psychological and is to be explained in terms of the unexpected and undefined nature of the situation.

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[1] From notes of lecture given by author. The lecture notes reproduced herein are based on the research and findings of various investigators in the field of disaster psychology. Acknowledgment is given to these investigators, especially to the authors of the publications listed in the footnotes.

[2] Head, Military Evaluations Group, U. S. Naval Radiological Defense Laboratory, San Francisco 24, Calif.

[3] ORO–T–194, A Study of the Effect of Catastrophe on Social Disorganization, Logan, Killian & Marrs (1951). (The rationale of this paper is drawn from pp. 94–96 and pp. 102–109 of the above reference.)

[4] S. H. Prince, Catastrophe and Social Change, vol. XCIV of Studies in History, Economics, and Public Law, Columbia University, 1920.

The Mann Gulch fire of 1949 was a forest-fire disaster in which 13 firefighters lost their lives. They were a group under the leadership of a man named Dodge, who, when it became evident that the group was trapped, set a small escape fire in the meadow. The escape fire created a burned area within which Dodge survived although the rest of the group failed to follow him. The report of the board of review [6] states:

"The evidence is not conclusive as to how many of the crew understood Dodge's purpose in setting the escape fire and heard his directions to join him inside the burned area. The situation was complicated by the noise of the main fire and possibly by the remark of one victim, as heard by some of the men, 'To hell with this, I am getting out of here.' Evidently each individual followed either his own interests at this point or the example of those ahead of him who were making their way up or across the slope."

"Dodge showed coolness and good judgment in setting the escape fire. Both survivors and Sylvia said they believed that all the men would have been saved if they had followed Dodge's lead in getting into the area burned by the escape fire."

This indeed is one of the major problems with which any atomic defense or disaster organization is faced. We know that role persons will arise in the situation. We know that some of these people will be playing roles that are highly desirable. We know that others may be playing roles that are going to increase the loss of life or are likely to interfere with the saving of life by others. A major effort must be made to assure that the roles that people play are those that are the proper ones in the total situation. Such an effort must also include role persons of the highest degree. For example, it has been stated that doctors are generally role persons. They will treat injured persons wherever they find them, irrespective of their own safety or thoughts about their loved ones. But this may not be the role that we would like to have a doctor play. It might be better for him to go immediately to a first-aid collecting station or a hospital where he can treat a vastly greater number of injured in the same period of time and with more effectiveness than he would be able to do in scrambling through the ruins. If this is the case, then the doctor must be trained to the proper role. He must be convinced that the proposed role is the best for him. Once he is convinced of this, it will guide his actions as a role person.

Other examples of improper roles have occurred in civil disasters. In one tornado incident, the police chief, rushing from his home toward his office, stopped on the main business street and became a mere guard, protecting the stores there from looting. The sheriff became directly involved in rescue work as a worker since several branches of his family had lived in the path of the tornado. These men played useful roles but they failed to assume the position of leadership for which they were qualified and which would have resulted in more effective disaster control.

Effective atomic defense will depend in large measure upon the number and type of role persons involved in the emergency. Effective leadership is more important than facilities or equipment. There is rarely anything needed in a disaster area that isn't already there—hardware stores full of tools, acres of abandoned vehicles, grocery stores full of food, department stores, hotels and motels, gas stations full of gas. What is usually in short supply are people who understand the jobs to be done and who do them.

It is interesting that military organizations have developed the role person concept to a high degree, perhaps without realizing it. Compared with civil populations, the military are therefore highly immune to disasters. Not only is the organizaiton able to take advantage of the basic human motivations in disaster, but there is a constant program in the military forces to develop every individual in the organization as a role person. The program starts with basic training and proceeds through successive stages by which men are trained to play particular roles under adverse circumstances.

There are degrees of role persons, and the military recognize this fact. When men are put into the front lines for the first time, the Army is usually careful

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[6] Report of Board of Review, Mann Gulch Fire, Helena National Forest, August 5, 1949, U. S. Forest Service.

to intersperse these green personnel among units that have combat experience. In this case, the combat veterans act as role persons and have a controlling influence in the action that ensues.

It would be an ideal state of affairs if an atomic attack we could have every person a role person playing a proper role. At the present time, this is far from the case and perhaps a more practical target should be proposed. As a rule of thumb, it may be said that if one can be sure that 1 person in 10 in a disaster area will act as a proper-role person, then control of the situation and maximum saving of life and property can result. That is, each role person can take with him, on the basis of silent leadership and example, something of the order of 10 other persons who otherwise might be doing nothing, doing the wrong things, or blindly attempting to escape a situation in which they can see no hope. Of course, it would be desirable to have more role persons than 1 in 10. Therefore, atomic defense organizations should aim at creating as many role persons as possible. Only in this way can we be sure that our people will have the maximum chance of survival.

Now let us return to the city of Halifax and the members of the Academy Stock Co. Why were these play actors heroes at Halifax? Whey were they role persons? Regardless of their other traits, actors are trained intensively in playing roles. Each evening they become another person. The degree to which they do become another person indicates their stature as an actor. One cannot know whether these actors had ever acted in a play involving a natural disaster but certainly they were adept at playing roles. When the disaster occurred, it was their natural impulse to play a role. The role they chose as a group to play turned out to be very excellent. Prince says, "Thus it came about that the soldiers, firemen, and play actors may be called the disaster protocracy. They were 'the alert and effective,' the most promptly reacting units in emergency."

Some conclusions with regard to atomic defense are warranted. Certainly one of the principal jobs is to create a large number of role persons and to train them to play the roles that are found to be the most important. While limited numbers of personnel are being organized and trained intensively, the broad base of the population should be indoctrinated with sufficient knowledge to encourage proper structuring of the situation. They should be exposed to the bare essentials regarding emergency action to save life—fighting fires, conducting rescue, and so on.

Existing primary groups at work locations, at home, and at school should be utilized in organizing for atomic defense. Supervisors, family heads, and teachers should be singled out for development into role persons. Their training must be such as to assure maximum protection and control of members of the group and to instill confidence in group members that control leadership will preserve life.

The immediate value of an organization in time of disaster is the ability to structure the situation more adequately and more quickly than the individuals involved. The magnitude of atomic effects makes this function particularly important. Communications are therefore essential to organized atomic defense. If the control center is not provided with the means of acquiring the necessary information on the nature and extent of the disaster, it may form a more erroneous structure of the situation than many subordinate elements or persons who are directly involved. In this event, attempts to control the actions of others will be fruitless. People involved in the disaster will usually ignore nonsensical instructions—instructions which patently are not in accord with the situation.

Of equal importance is the provision of adequate communications for the dissemination of a structure to the whole target population. It is not enough to advise a limited organization while the vast majority of the survivors are forming their own structure and proceeding to act accordingly.

Finally, all disaster organizations should be open-ended; they must not be conceived as a closed corporation. Members of atomic defense organizations should all be trained as leaders. They should be alert to recognize emergent-role persons in a disaster and quick to accept and utilize their valuable efforts. Any disaster plan that depends entirely upon the predisaster organization is a bad plan. The door must be left open for nonmembers to help. When the chips are down, they will help—better than many.

W. E. Strope.

EXHIBIT 3

RADIOLOGICAL DEFENSE MEASURES AS A COUNTERMEASURE SYSTEM

Research and Development Technical Report USNRDL-TR-74, NS083001, February 15, 1956, by W. E. Strope

General, Technical Objective AW-5c

Military Evaluations Group

W. E. Strope, Head

Scientific Director, P. C. Tompkins

Commanding Officer and Director, Capt. R. A. Hinners, United States Navy

UNITED STATES NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO, CALIF.

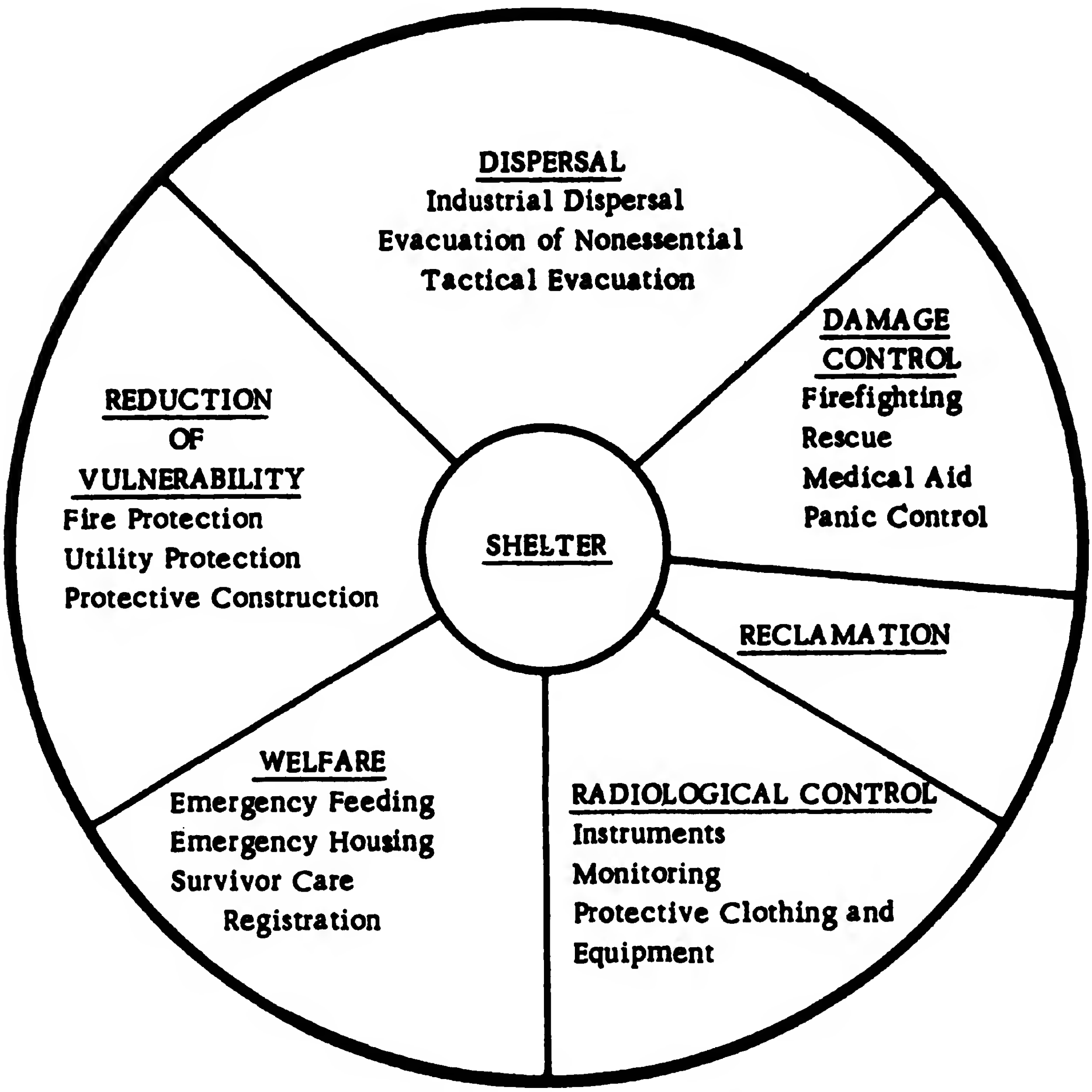


Fig. 1 Countermeasure System in the Emergency Phase

Hon. Val Peterson, Federal Civil Defense Administration Chief, in a speech before the Helicopter Association of America in San Francisco on January 24, 1956, stated: "Today we can give warning of an attack in time for evacuation of the city, but when the guided missile is fully developed then it will be a case of 'take shelter where you can.'"

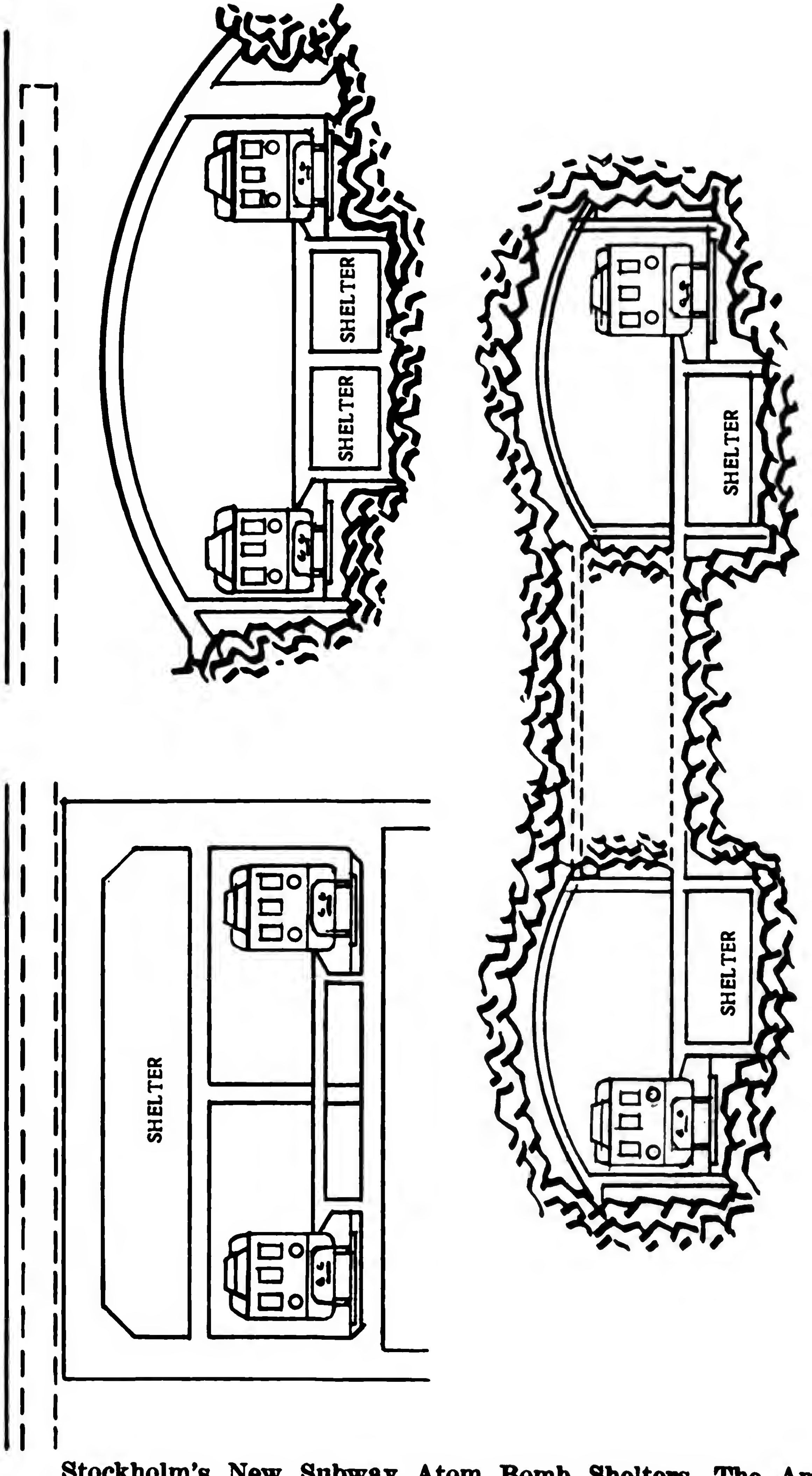


Fig. 2 Shelters in Stockholm Subway (Illustration adapted, courtesy of The American Swedish Monthly

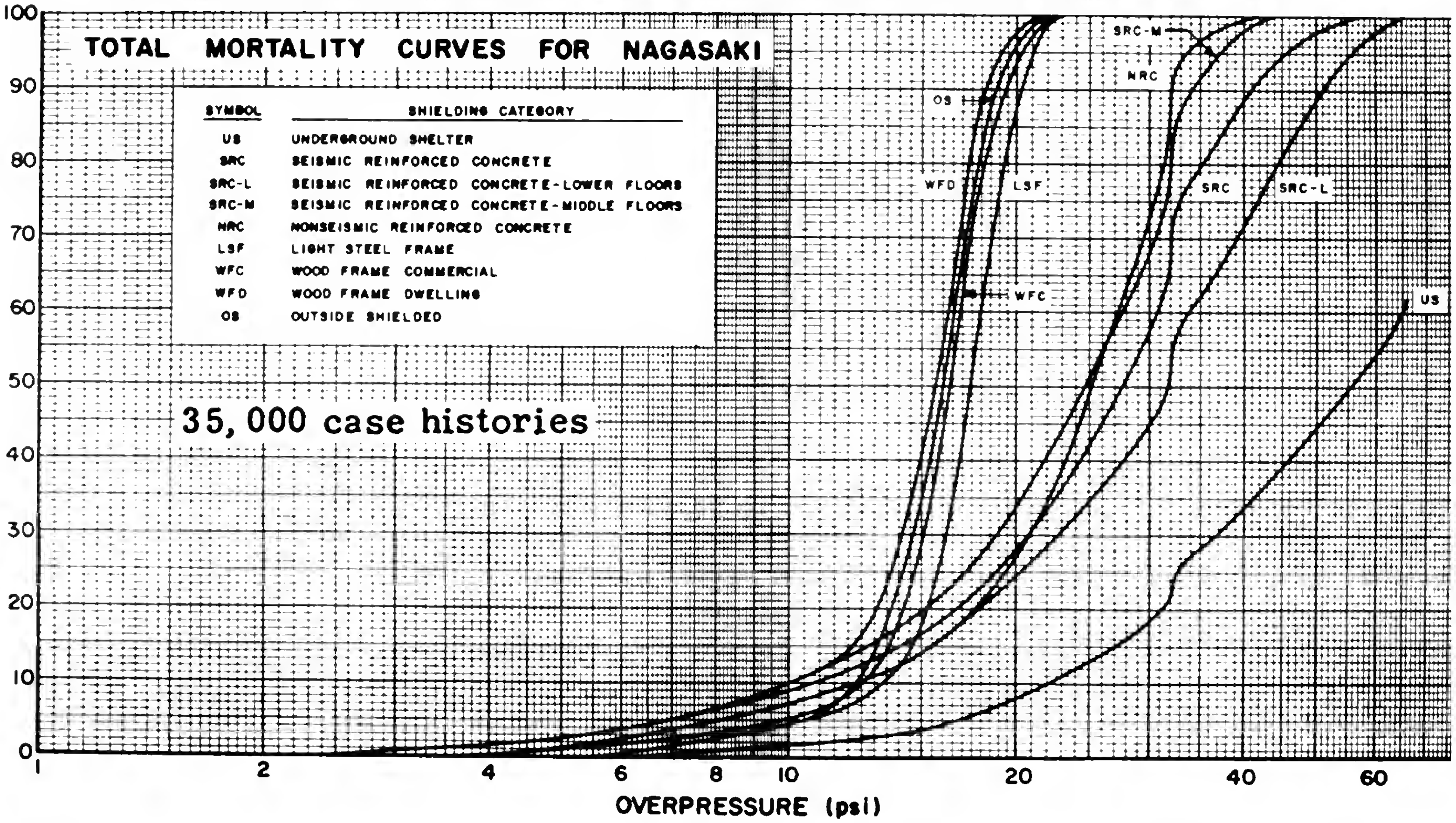
Three types of shelter. Upper left - over the train platform. Right - below the train platform. Lower - under each platform for trains in opposite directions.

Stockholm's New Subway Atom Bomb Shelters, The American Swedish Monthly, vol. 47, No. 1:6, January 1953.

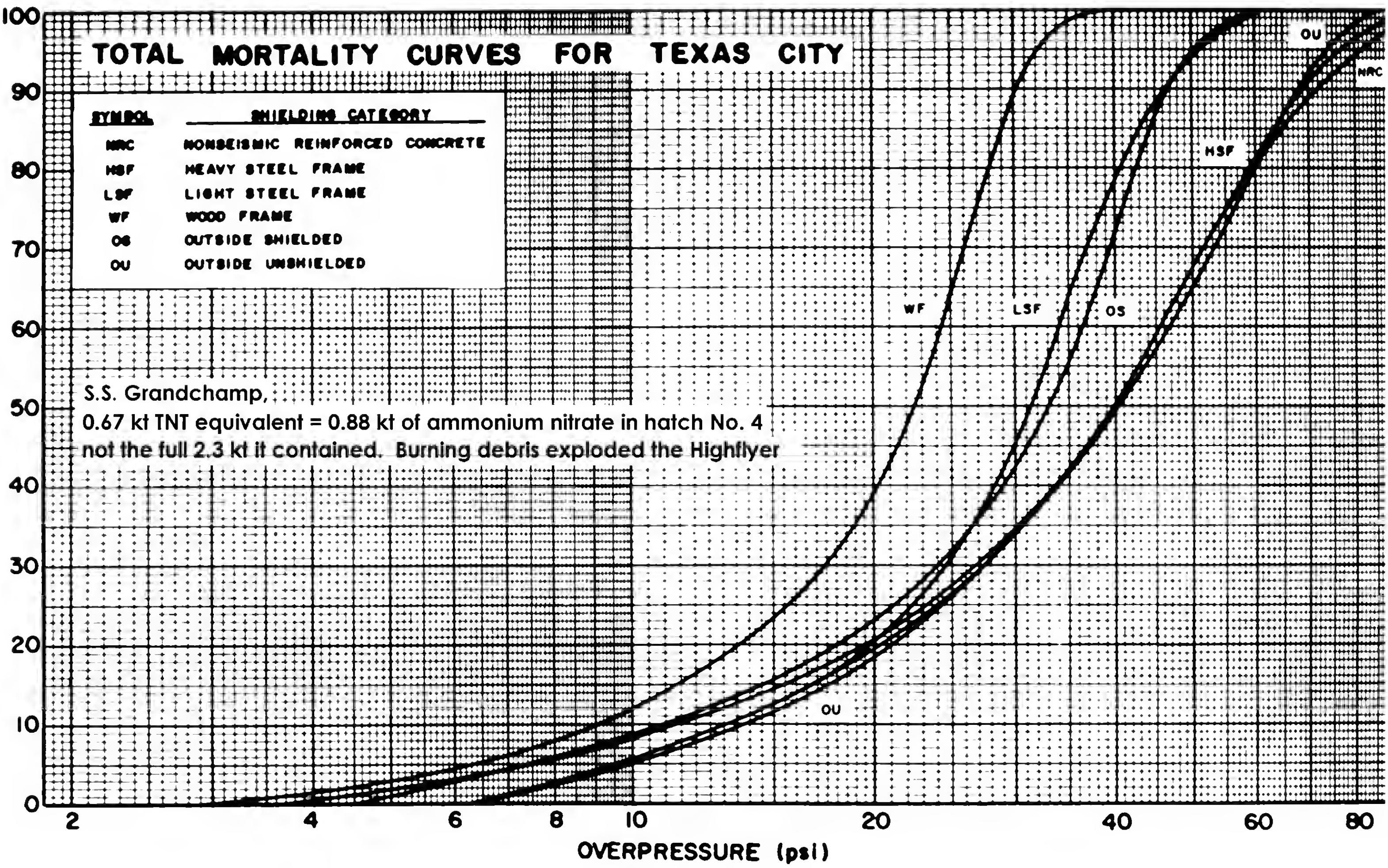
Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

For people in or shielded by structures in Japan, the blast and initial-nuclear radiation were the dominant immediate effects.



S.S. Grandchamp at Texas City exploded in 1947. It contained 2.3 kt of ammonium nitrate in 100-lb paper bags, but only the 0.88 kt in No. 4 hatch was tamped and exploded after catching fire. TNT equivalent was 0.67 kt.



1979 U.S. Office of Technology Assessment, "The Effects of Nuclear War" deceptions

Table 14.—Long-Term Radiation Effects From Nuclear Attacks

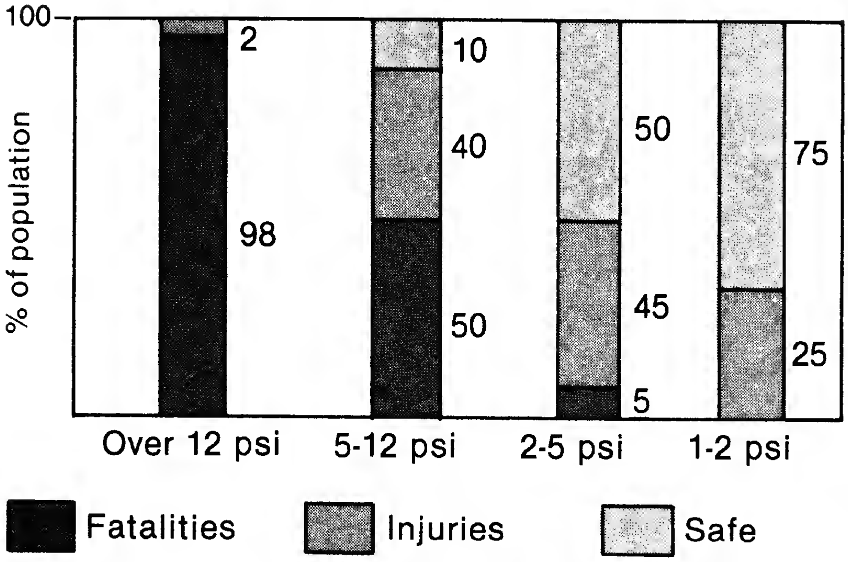
Estimated worldwide[b] effects from 1-Mt air burst over a city (OTA Case 1):

Somatic effects	
Cancer deaths	200 - 2,000
Thyroid cancers	about 700
Thyroid nodules	about 1,000
Genetic effects	
Abortions due to chromosomal damage	100 - 1,000
Other genetic effects	350 - 3,500

[b]Most worldwide fallout would be in the Northern Hemisphere

Above: false LNT radiation scaremongering

Figure 1.—Vulnerability of Population in Various Overpressure Zones



Damage to unreinforced brick house (5-psi overpressure)

Above: false house collapse (Apple-2 test house after manually demolished!) photo. In fact, outer walls exploded but 1st floor did not collapse at 5 psi, and outward debris motion reduced hazard!

Blast exaggeration:

Table 4.—Casualty Estimates (in thousands) (1 Mt on Detroit)

Region (mi)	Area (mi²)	Population	Fatalities	Injuries	Uninjured
0-1.7	9.1	70	70	0	0
1.7-2.7	13.8	250	130	100	20
2.7-4.7	46.5	400	20	180	200
4.7-7.4	102.6	600	0	150	450

Exaggerated blast effects table ignores modern city concrete buildings which resist blast collapse

Table 5.—Burn Casualty Estimates (1 Mt on Detroit)

Exaggerated thermal burns table "arbitrarily" assumes 6.7 cal/cm^2 is lethal and 3.4 cal/cm^2 hospitalizes.

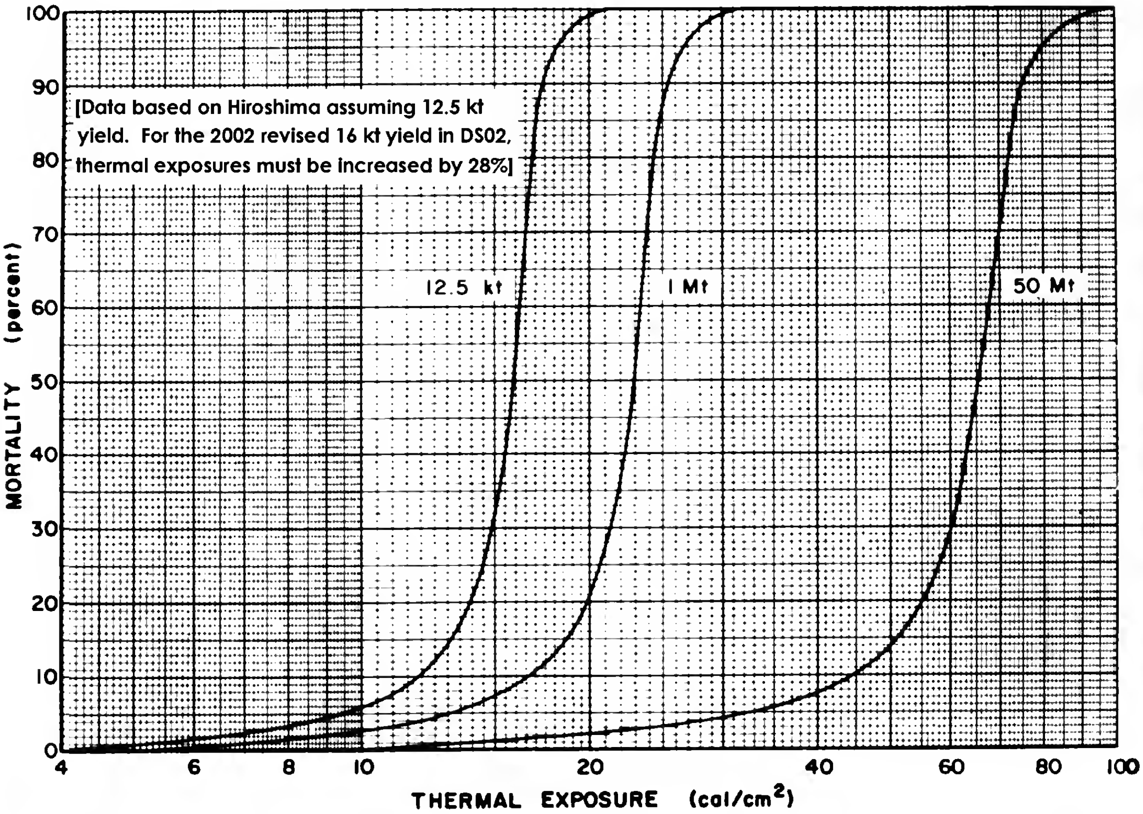
This was not true even for light clothing in Hiroshima and for bigger yields even more heat is needed! Skyline shadowing protects over 90%.

Distance from blast (mi)	Survivors of blast effects	Fatalities (eventual)		Injuries	
		2-mile visibility	10-mile visibility	2-mile visibility	10-mile visibility
(1 percent of population exposed to line of sight from fireball)					
0-1.7	0	0	0	0	0
1.7-2.7	120,000	1,200	1,200	0	0
2.7-4.7	380,000	0	3,800	500	0
4.7-7.4	600,000	0	2,600	0	3,000
Total (rounded)		1,000	8,000	500	3,000
(25 percent of population exposed to line of sight from fireball)					
0-1.7	0	0	0	0	0
1.7-2.7	120,000	30,000	30,000	0	0
2.7-4.7	380,000	0	95,000	11,000	0
4.7-7.4	600,000	0	66,000	0	75,000
Total (rounded)		30,000	190,000	11,000	75,000

These calculations arbitrarily assume that exposure to more than 6.7 cal/cm² produces eventual death, and exposure to more than 3.4 cal/cm² produces a significant injury, requiring specialized medical treatment.

L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS FOR OUTSIDE-UNSHIELDED PERSONS



Unless you are nude outdoors, 6.7 cal/cm^2 is not lethal, contrary to the OTA report!

Shirt protection: Nagasaki

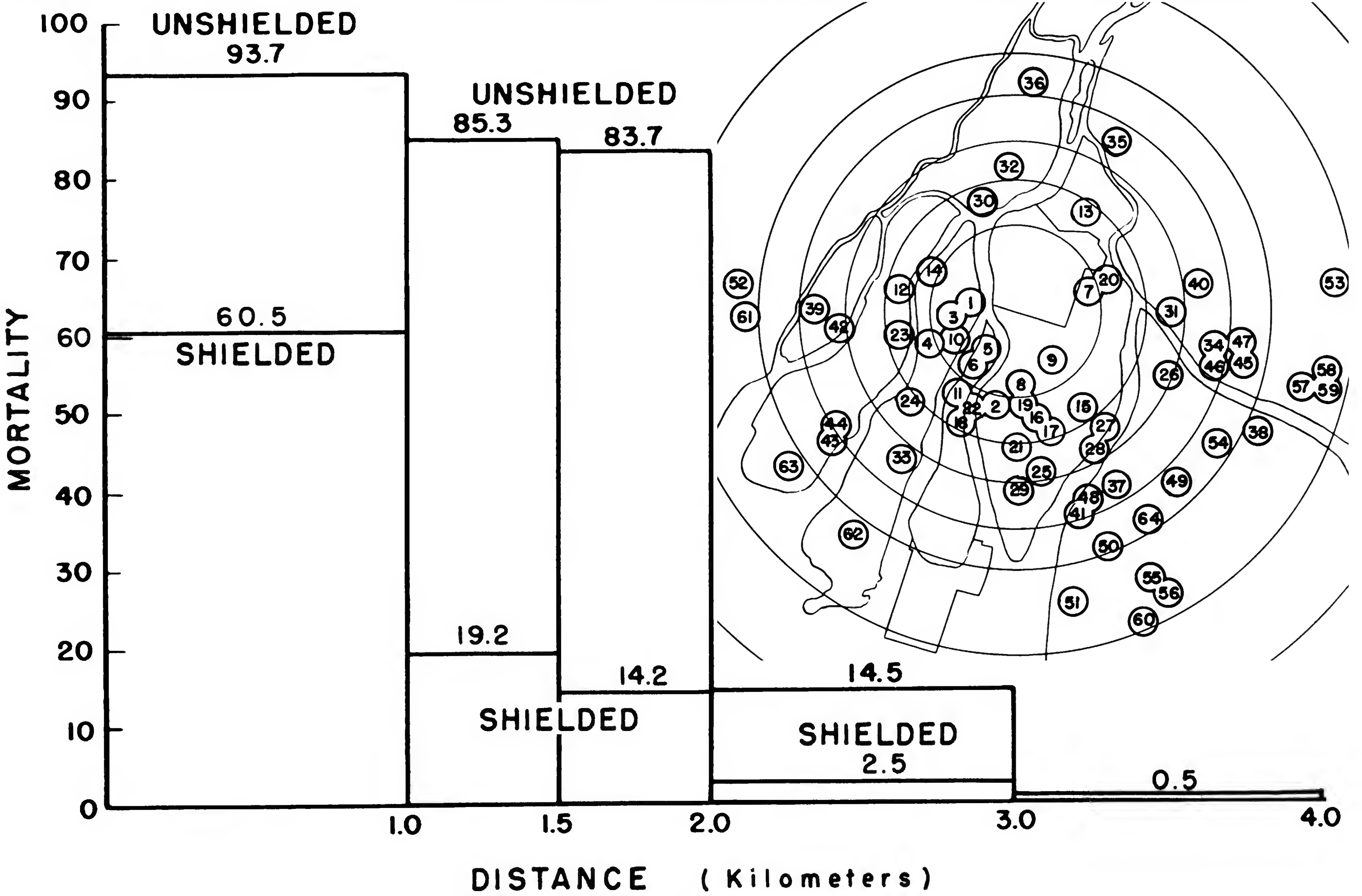
Uniform protection: Hiroshima, "lethal" 6.7 cal/cm^2 !!!

PROTECTION AGAINST RADIANT HEAT. This patient (photographed by Japanese 2 October 1945) was about 6,500 feet from ground zero when the rays struck him from the left. His cap was sufficient to protect the top of his head against flash burns.

Above: Hiroshima soldier only burned on unclothed skin (1946 USSBS report on Hiroshima and Nagasaki, page 16)

HIROSHIMA SCHOOL CHILDREN

WORK PARTIES DISTRIBUTION



HOME OFFICE

CD/SA 121

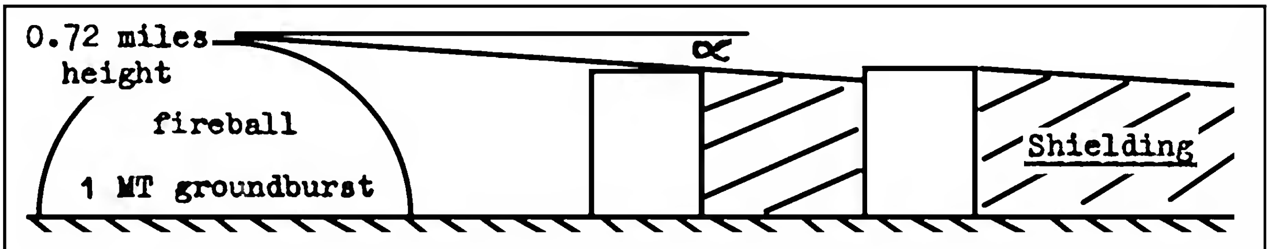
SCIENTIFIC ADVISER'S BRANCH

(Paper at Tripartite Thermal Effects Symposium, Dorking, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE



Thermal pulse precedes the blast wave

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height we take the average depth of a floor to be 10 ft.

Effect of Shielding: Estimation of the number of exposed floors

Distance from explosion	Angle of arrival	Width of street (units of 10 ft.)						
miles	α^{o}	2	3	4	5	6	7	8
3	$13\frac{1}{2}$	.5	.5	1	1	1.5	1.5	2
4	10	.5	.5	.5	1	1	1.5	1.5
5	8	.5	.5	.5	.5	1	1	1

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the fire-storm raid on Hamburg, 27th/28th July, 1943

102 tons H.E.	48 tons, 4 lb. magnesium	40 tons, 30 lb. gel.
100 fires	27,000 bombs	3,000 bombs
	8,000 on buildings	900 on buildings
	1,600 fires	800 fires

2,500 fires in 6,000 buildings

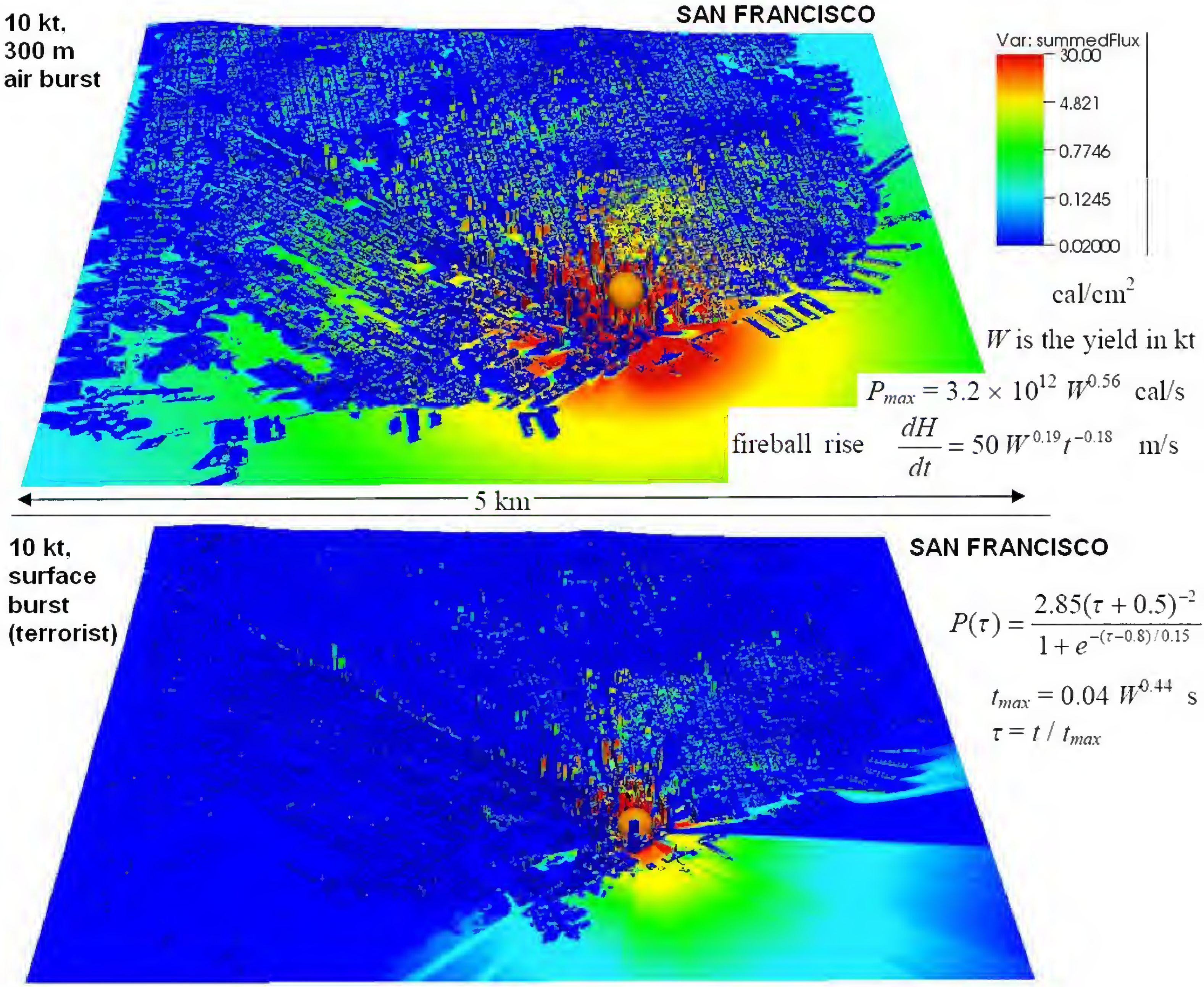
However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire

When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of ~ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, and B. Whitlock
Lawrence Livermore National Laboratory

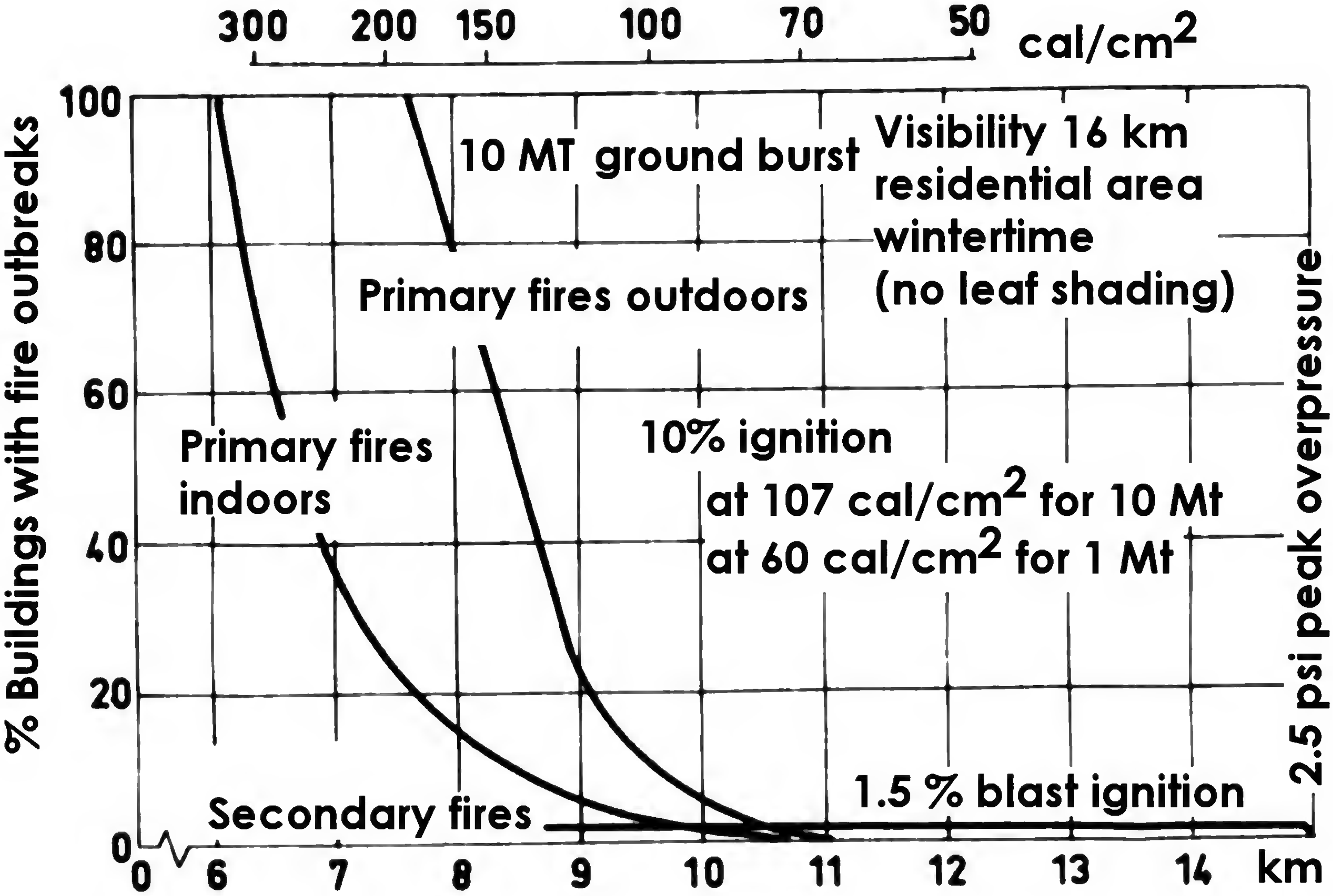
UCRL-TR-231593
June 7, 2007

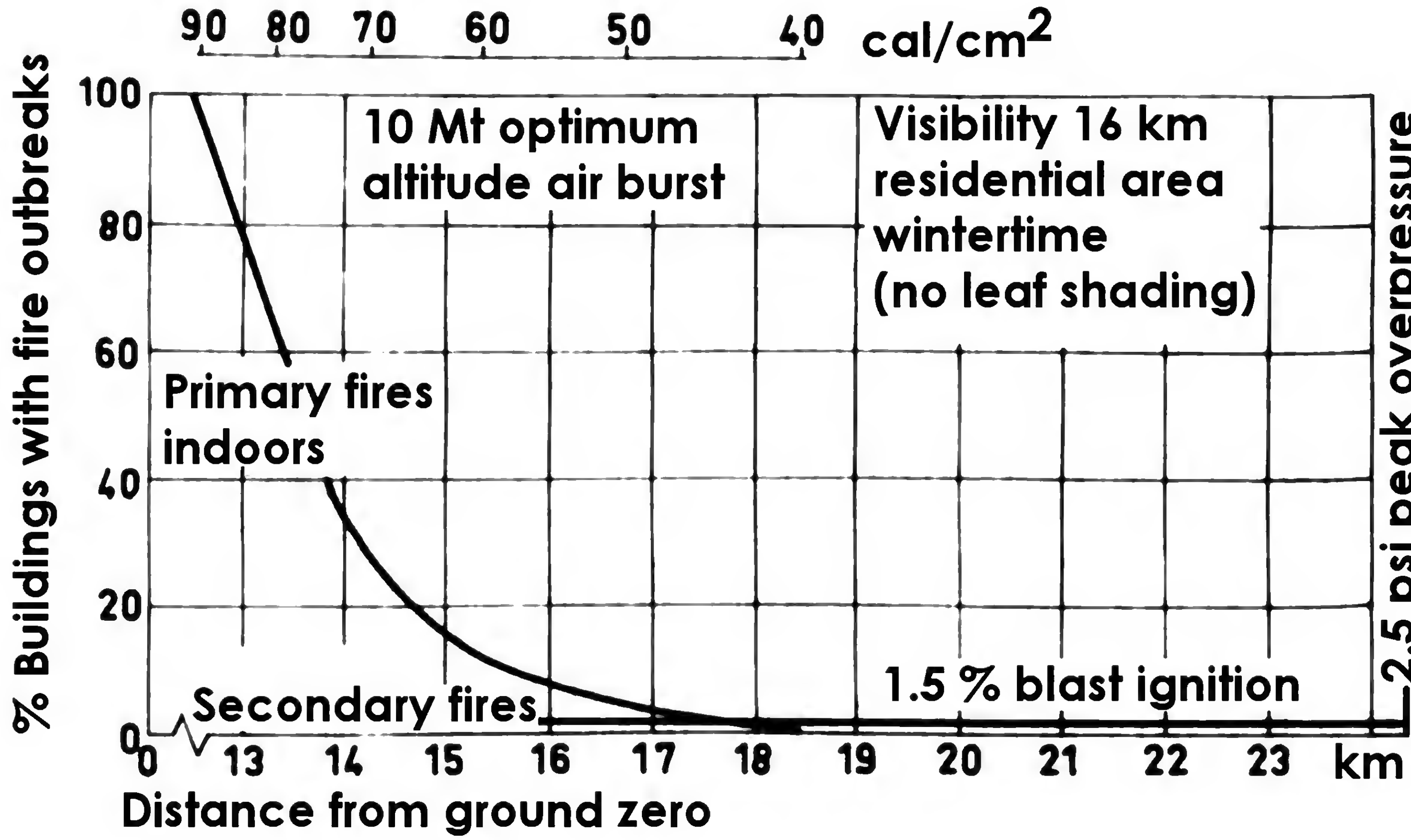


Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

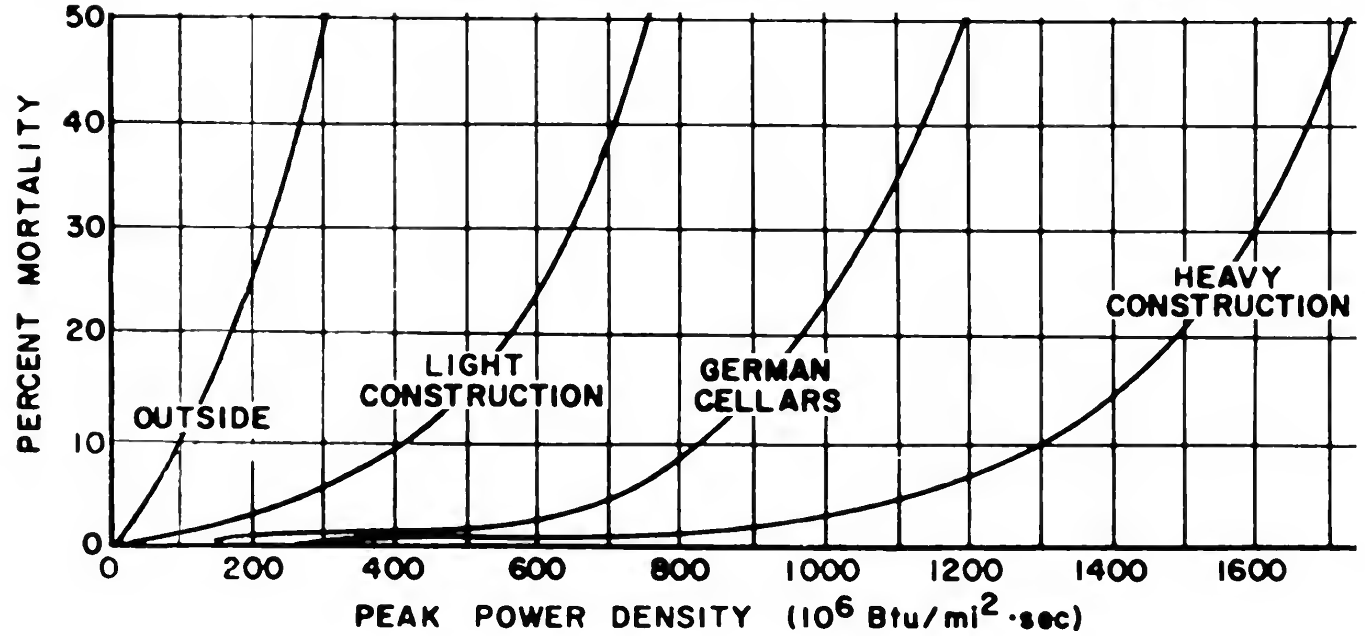
We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

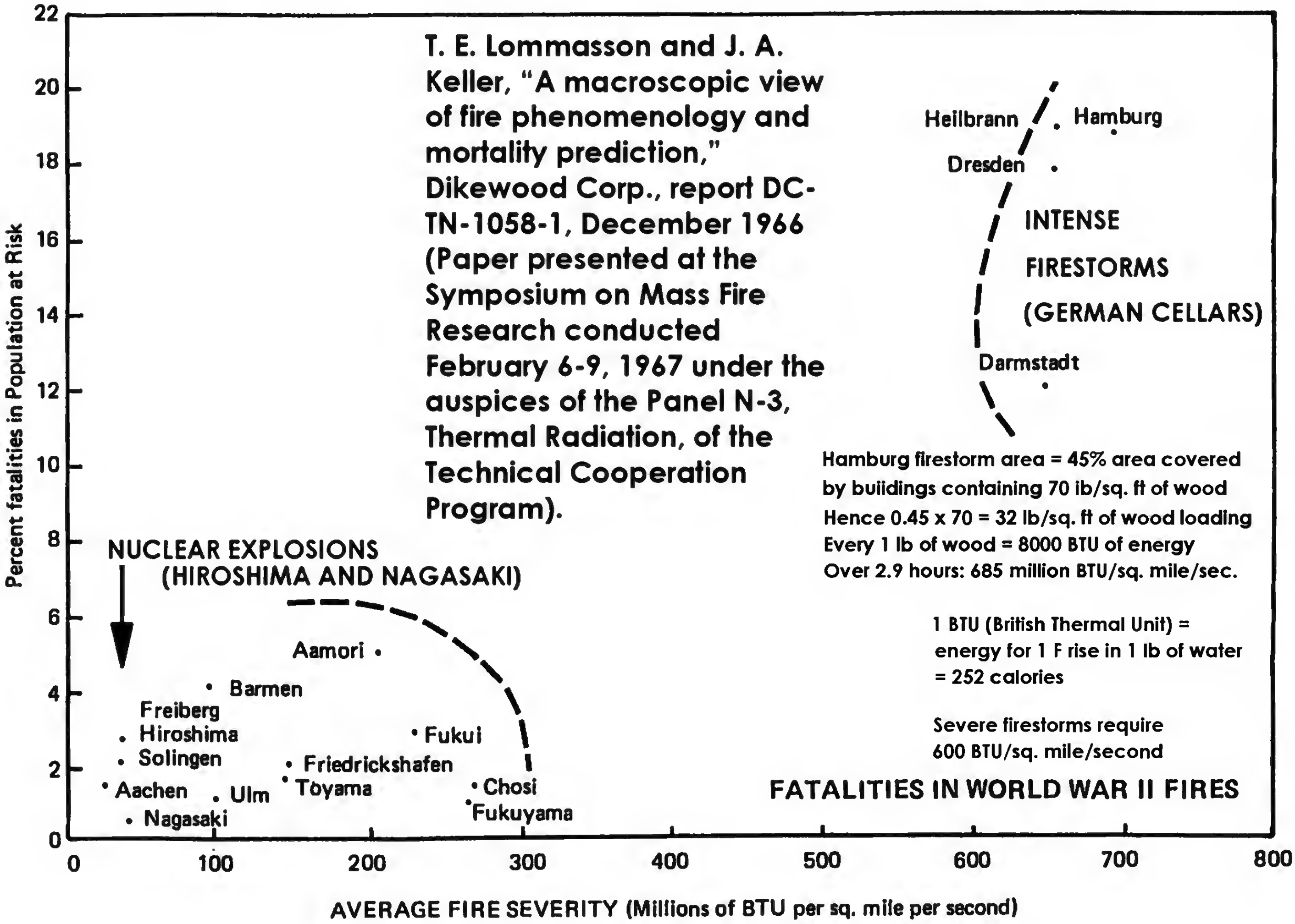
John L. Crain, et al., Supplemental Analysis - Civil Defense Rescue, Stanford Research Institute, AD0625802, 1965.





FIRE MORTALITY CURVES

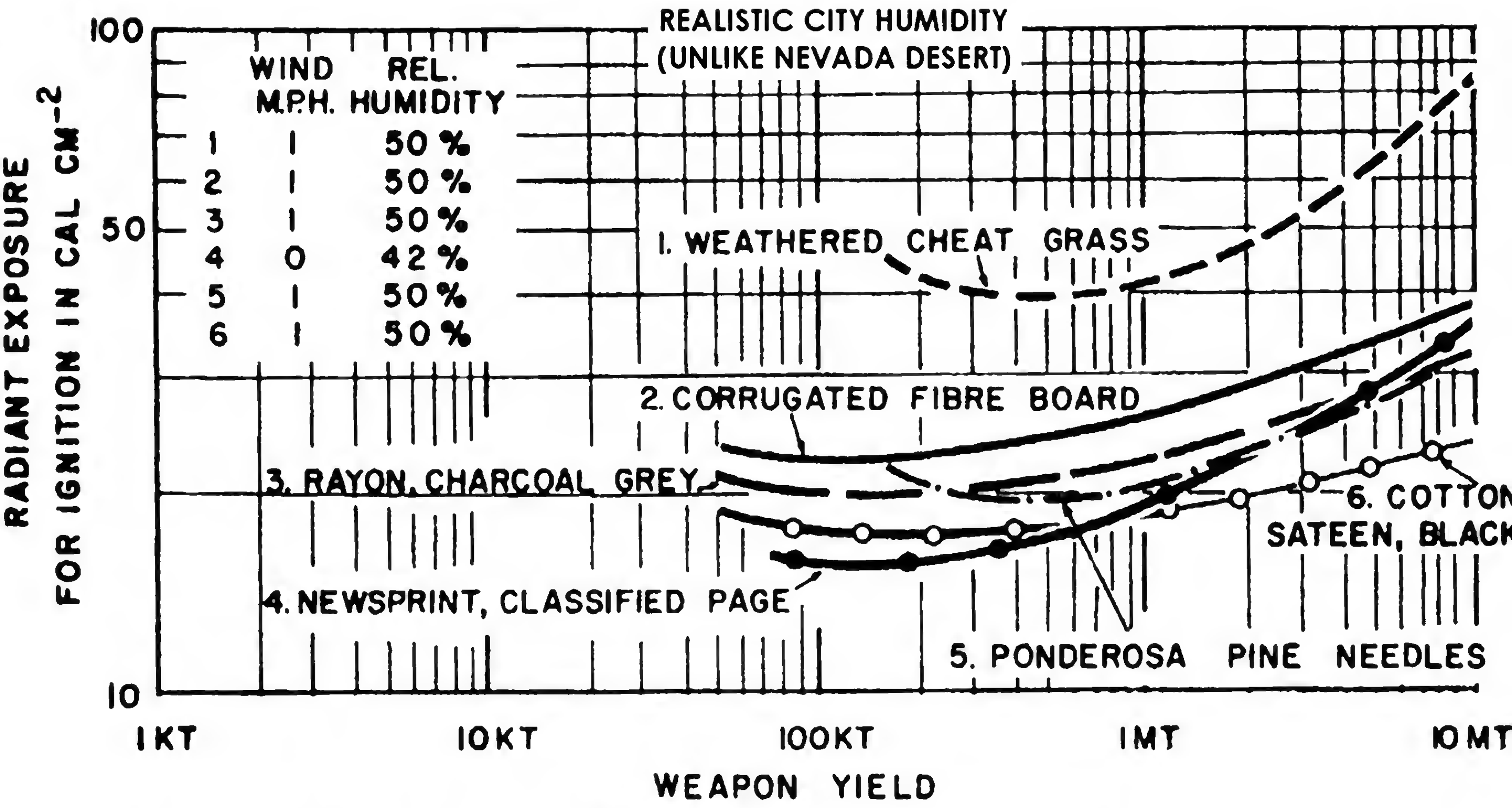




Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions**, Dikewood Corporation, DC-TN-1058-1, December 1966.

J. A. Keller, A Study of World War II German Fire Fatalities, DC-TN-1050-3, The Dikewood Corporation; April, 1966.

R. Schubert, Examination of Building Density and Fire Loading in the Districts Eimsbuettel and Hammerbrook of the City of Hamburg in the Year 1943 (20 volumes, in German), Stanford Research Institute; January, 1966.



"TECHNICAL OBJECTIVE AW-7, CRITICAL RADIANT EXPOSURES FOR PERSISTENT IGNITION", JULY 1960, J. BRACCIAVENTI & F. DEBOLD AD-249476; DASA-1194

UCRL-TR-231593

Thermal radiation from nuclear detonations in urban environments

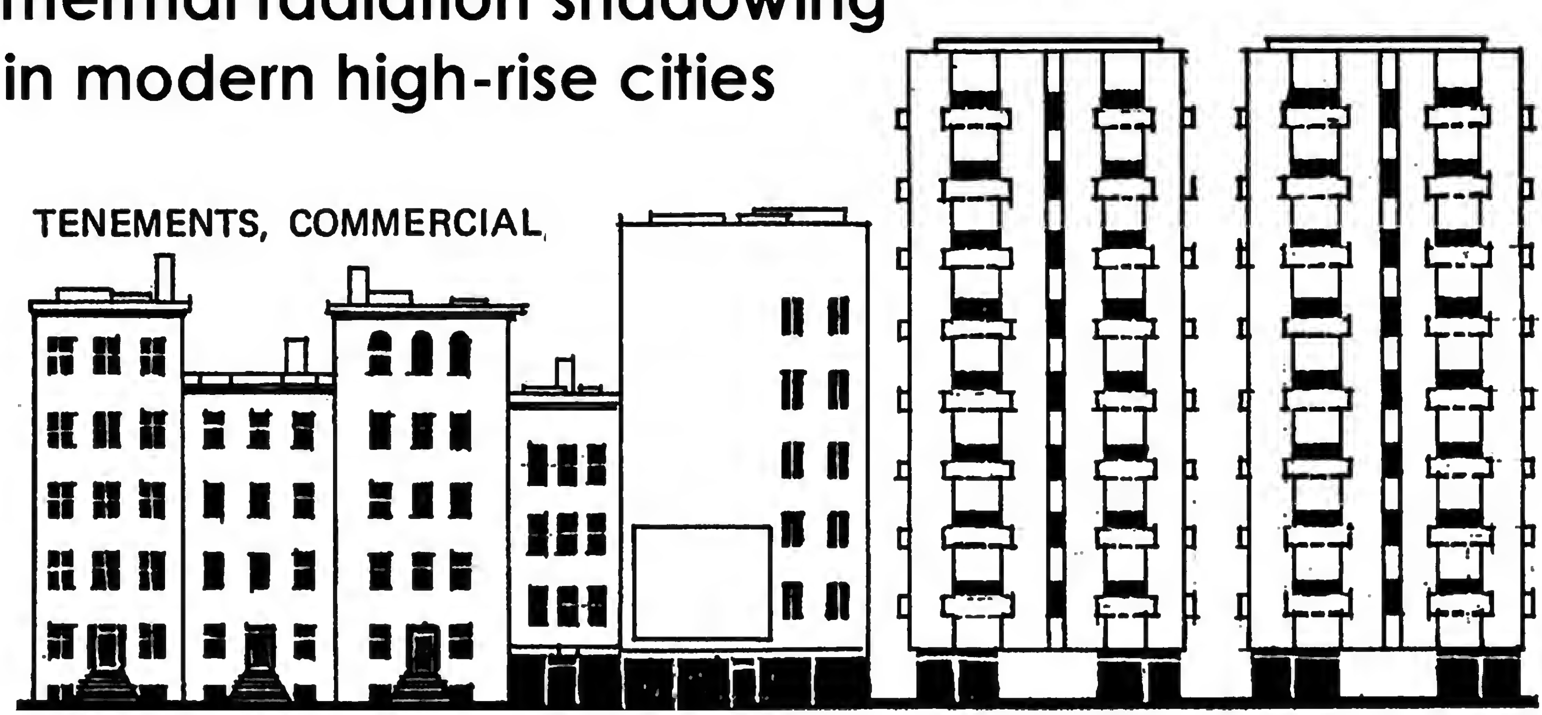
LAWRENCE LIVERMORE NATIONAL LABORATORY

June 7, 2007

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

Thermal radiation shadowing in modern high-rise cities



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OPERATION UPSHOT-KNOTHOLE

Project 8.5

THERMAL RADIATION PROTECTION AFFORDED TEST ANIMALS BY FABRIC ASSEMBLIES

REPORT TO THE TEST DIRECTOR

by

J. Fred Oesterling and Staff

REGRADED UNCLASSIFIED

BY AUTHORITY OF DA Form 1575 FCAG/2 Std 6 Aug 63 274/24

BY B. W. [illegible] 23 Sep 64

July 1955

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Quartermaster Research and Development Laboratories
Army Medical Service Graduate School
Walter Reed Army Medical Center
University of Rochester Atomic Energy Project

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4.1.2 Factors Contributing to the Greater Degree of Thermal Protection in the Field.

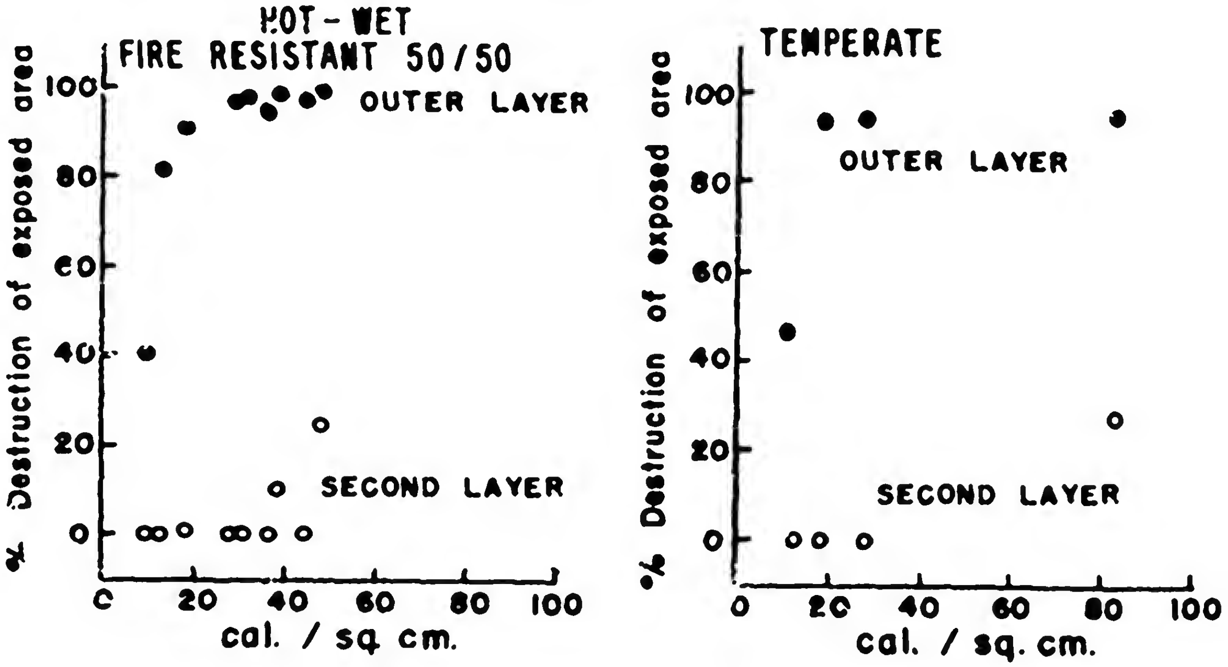
There are several conditions encountered in the field, especially at the higher energy levels, but not duplicated in the laboratory (at least not up to the present time) that may account for the fact that like amounts of thermal energy did not produce comparable results in the laboratory and in the field. First, the thermal energy is delivered much more rapidly with the explosion of an atomic bomb than it is in the laboratory. Second, due to smoke obscuration the animals in the field actually received a smaller percentage of the total energy delivered than they did in the laboratory. Third, the blast wave following the explosion tended to extinguish flames and remove char, whereas no such wave was present in the laboratory tests. Fourth, where the heat reached the fabric layer next to the skin, uniform drape (or spacing) provided additional protection in the field.

(2) Motion pictures of clothed animals, exposed to 50.0 and 33.5 cal/cm^2 on Shots 9 and 10 respectively, showed heavy clouds

of black smoke enveloping the animals within 120 ms of the explosion.

(3) The blast wave following the explosion, which has not been duplicated in laboratory applications of thermal energy, has two possible protective effects. First, it can be expected to extinguish flames induced by the radiation in assemblies not treated for fire resistance, thus removing a source of high heat. Although the blast wave may not actually extinguish the flame in all cases,* it can be expected in general to have this effect. Second, the blast wave would tend to remove any char which, if allowed to remain, would act as a heat reservoir and increase the likelihood of a severe burn.

Fig. 3.5 Destruction of Outer and Second Layers of Pigs' Uniforms (Shots 9 and 10)



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WT-774

Copy No. 186 A

Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

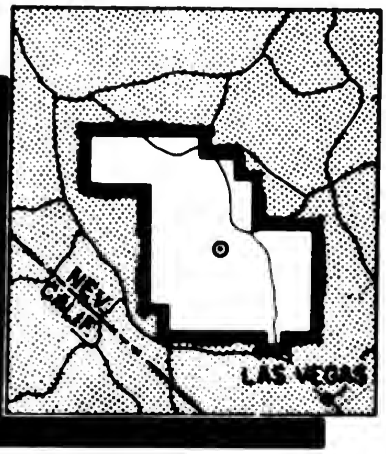
Project 8.11a

INCENDIARY EFFECTS ON BUILDING AND INTERIOR KINDLING FUELS

(ENCORE EFFECT REPORT)

27 kt at 2,423 feet altitude, 19% humidity

(DASA-1251) (Note: cities humidity is ~50-80%)



RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1946. Its transmittal or the disclosure of its contents in any manner to an unauthorized person is prohibited.

HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

CONFIDENTIAL

Weapon test report WT-774, Project 8.11a, Incendiary effects on buildings and interior kindling fuels

ENCORE test, Nevada, 1953
10' x 12' wooden houses with 4' x 6' windows
17 calories/sq. cm thermal flash

Immediate room flashover during thermal pulse
("Encore effect") in inflammables-filled house
while fire-resistant fabrics in other house survived!

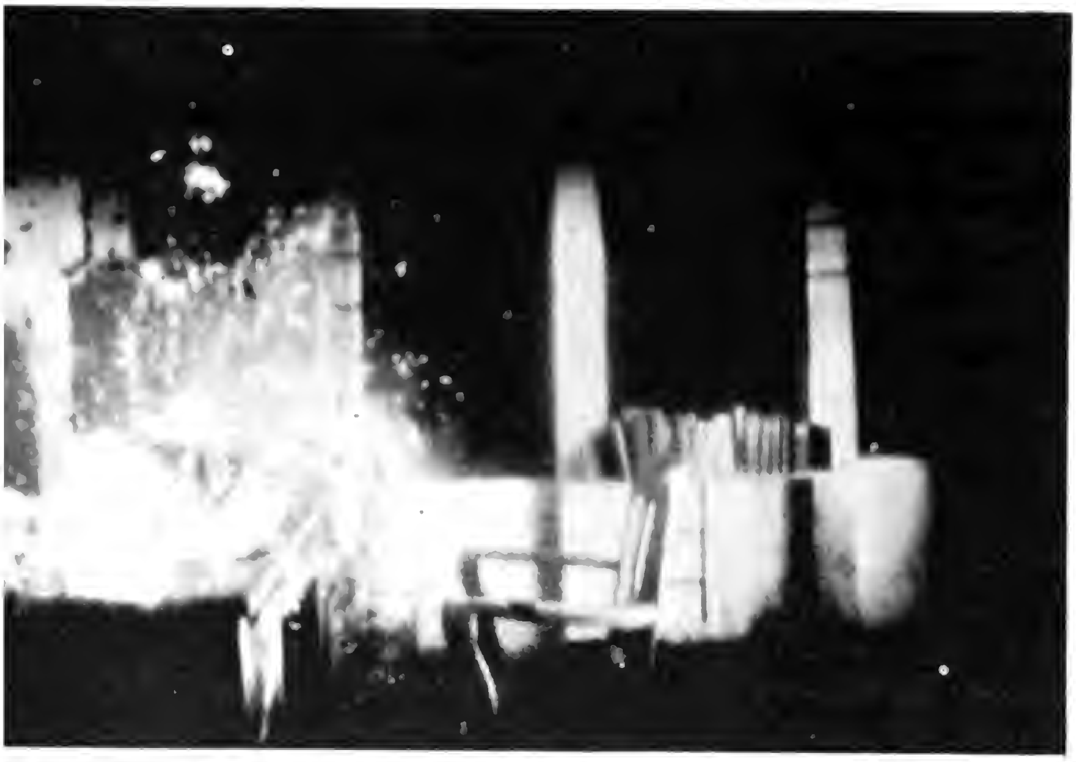
LEFT HOUSE: fire-resistant furnishings
(woolen rugs and clothes, vinyl plastic draperies)

RIGHT HOUSE: non-fire resistant furnishings
plus inflammable magazines and newspapers

Smouldering armchair extinguished 1 hour after detonation, when recovery party arrived at house

EFFECTS OF 1 PSI OVERPRESSURE ON IGNITIONS

From: Goodale, Effects of Air Blast on Urban Fires URS 7009–14 Dec. 1970 (AD 723 429)



Blast winds both cool burning material and upset flame convection system.

50% of burning curtains are extinguished by 1 psi overpressure

100% are put out by 2.5 psi. Note that burning LIQUIDS in high-wall trays are not put out by blast waves, but this is not relevant to city fires.

Burning beds can continue to smoulder until extinguished with water.

3rd October, 1963.

~~RESTRICTED~~ Foa Pr
9/7/89

HOME OFFICE

SCIENTIFIC ADVISER'S BRANCH

CD/SA 116

RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about $\frac{1}{3}$ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

Large-Scale Field Test ($^1/40$) at Suffield, Alberta

The test is fully described in an A.W.R.E. report(6). The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at $^1/40$th scale, that had already been tested at $^1/117$ scale.

Blast Entry from Stations

There was remarkable agreement with the $^1/117$th scale trials: "maximum overpressure in the train tunnels was of the order of $\frac{1}{3}$rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about $^1/6$th those in the corresponding incident blast .... ".

(6) $^1/40$th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62. (Official Use Only.)

100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961

Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

200 FT FROM GROUND ZERO	400 FT FROM GROUND ZERO
100 PSI OUTSIDE	20 PSI OUTSIDE
30 PSI IN TUBES	7.2 PSI IN TUBES
15 PSI IN TUBE STATIONS	4.3 PSI IN TUBE STATIONS

Aldwych Underground tube station as Blitz shelter, 8 October 1940

Aldwych tube London 21 Oct 1940: effective Blitz air raid shelter

THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume I

Physical Damage Division

May 1947

G. CAUSE AND EXTENT OF FIRE

1. Conditions Prior to Attack

The city of Hiroshima was an excellent target for the atomic bomb from a fire standpoint: There had been no rain for three weeks; the city was highly combustible, consisting principally of Japanese domestic-type structures; it was constructed over flat terrain; and 13 square miles (including streets) of the 26.5-square-mile city was more than 5 percent built up (i. e., covered by plan areas of buildings). The remainder of the city comprised water areas, parks and areas built up below 5 percent. Sixty-eight percent of the 13-square-mile area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 93.6 percent of it being 27 to 42 percent built up.

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a. Evidence relative to ignition of combustible structures and materials by heat directly radiated by the atomic bomb and by other ignition sources developed the following: (1) The primary fire hazard was present in combustible materials and in fire-resistive buildings with unshielded wall openings; (2) six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by radiant heat; (3) a few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion; (4) dark clothing was scorched, and, in some cases, reported to have burst into flame from flash heat; (5) but a large proportion of over 1,000 persons questioned was in agreement that a great majority of the original fires was started by debris falling on kitchen charcoal fires, by industrial process fires, or by electric short circuits.

b. Hundreds of fires were reported to have started in the center of the city within ten minutes after the explosion. Of the total number of buildings investigated 107 caught fire, and, in 69 instances, the probable cause of initial ignition of the buildings or their contents was established as follows: (1) 8 by direct radiated heat from the bomb (primary fire), (2) 8 by secondary sources and (3) 53 by fire spread from exposing buildings.

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3. Conditions on Morning of Attack

a. The morning of 6 August 1945 was clear with a small amount of clouds at high altitude. Wind was from the south with a velocity of about 4½ miles per hour. Visibility was 10 to 15 miles.

(1) Only a few persons remained in the air-raid shelters after the "all-clear" sounded.

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THE UNITED STATES STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume II

Physical Damage Division

Dates of Survey:

14 October–26 November 1945

Date of Publication

May 1947

4. The city, consisting principally of Japanese domestic structures, was highly combustible and densely built up. Sixty-eight percent of the 13-square-mile city area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 94 percent of it being 27 to 42 percent built up. All the large industrial plants were located on the south and southeast edges of the city.

8. Evidence relative to ignition of combustible structures and materials by directly radiated heat from the atomic bomb and other ignition sources was obtained by interrogation and visual inspection of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion. Dark clothing was scorched and, in some cases, was reported to have burst into flame from flash heat. A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. Other sources of secondary fire were industrial-process fires and electric short circuits.

9. There had been practically no rain in the city for about 3 weeks. The velocity of the wind on the morning of the atomic-bomb attack was not more than 5 miles per hour.

10. Hundreds of fires were reported to have started in the center of the city within 10 minutes after the explosion.

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PHOTO 36 IX. Shows partly burned coat of boy who was in open near City Hall (Building 28) 3,800 feet from AZ.

(8) Scores of persons throughout all sections of the city were questioned concerning the ignition of clothing by the flash from the bomb. Replies were consistent that white silk seldom was affected, although black, and some other colored silk, charred and disintegrated. Numerous instances were reported in which designs in black or other dark colors on a white silk kimono were charred so that they fell out, but the white part was not affected. These statements were confirmed by United States medical officers who had been able to examine a number of kimonos available in a hospital. Ten school boys were located during the study who had been in school yards about 6,200 feet east and 7,000 feet west, respectively, from AZ. These boys had flash burns on the portions of their faces which had been directly exposed to rays of the bomb. The boys' stories were consistent to the effect that their clothing, apparently of cotton materials, "smoked," but did not burst into flame. Photo 36 shows a boy's coat that started to smolder from heat rays at 3,800 feet from AZ.

(3300 from GZ)

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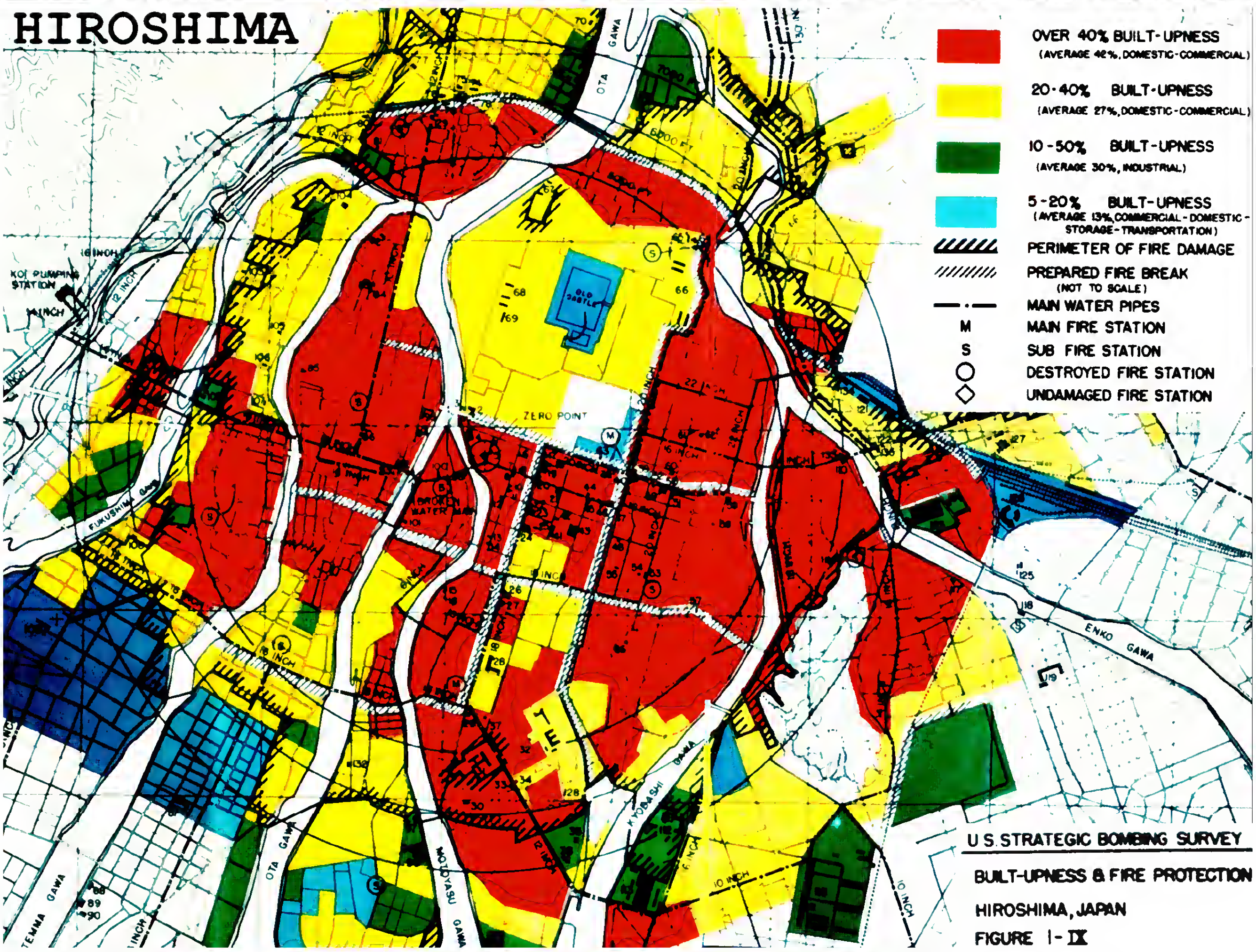

SOURCE: USSBS's report, "The Effects of the Atomic Bomb on Hiroshima, Japan," vol. 2

Only 8 of 64 non-wood buildings had thermal flash ignition evidence, 3 had blast damage induced fire, and 28 were ignited by firespread from wood homes.

D. THE CONFLAGRATION

1. Start of Fire

b. Direct Ignition by the Atomic Bomb. (1) Six persons were found who had been in reinforced-concrete buildings within 3,200 feet of AZ at the time of the explosion and who stated that black cotton black-out curtains were blazing a few seconds later. In two cases it was stated that thin rice paper on desks close to open windows facing AZ also burst into flame immediately, although heavier paper did not ignite. No incidents were recounted to the effect that furniture or similar objects within buildings were ignited directly by radiated heat from the bomb.

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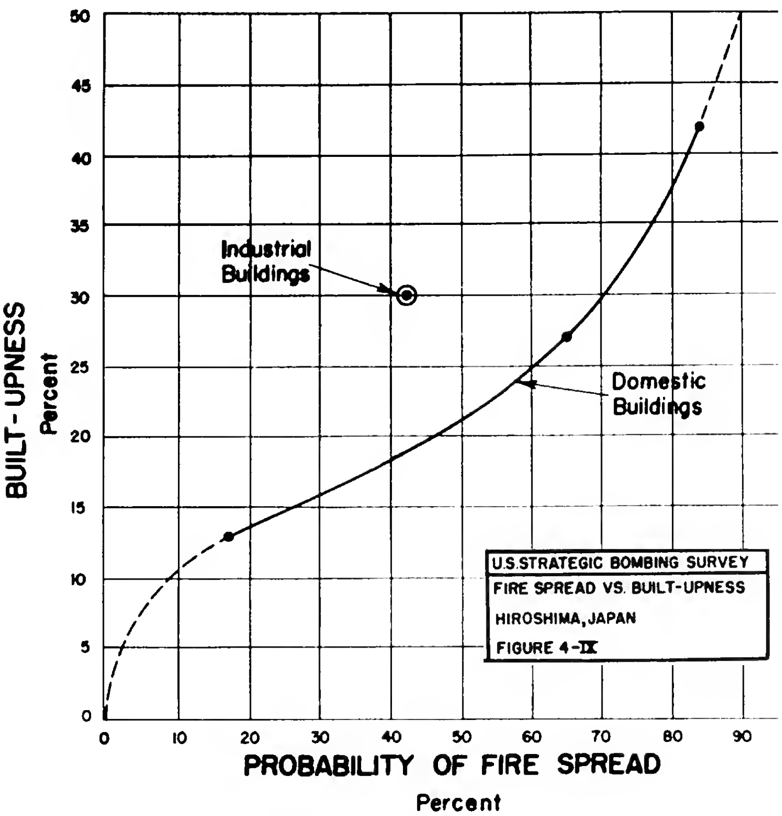

(4) It was reported that a cotton black-out curtain at an unprotected window in the east stair tower of Building 85 (3,800 feet from AZ) smoked and was scorched by radiated heat from the bomb but it did not burst into flames.

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(5) A man who was in the third story of building 26 (3,000 feet from AZ) stated that radiated heat from the bomb ignited cotton black-out curtains at unprotected windows in the west wall and thin rice paper on desks.

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(10) Fire fighting with water buckets was reported inside only four buildings (24, 33, 59, and 122) and probably prevented extensive fire damage in them. In Building 24, fire was started in contents of a room at the southwest corner of the second story by sparks from trees on the south side about 1½ hours after the attack. Men inside the building extinguished the fire and probably prevented further damage in the first and second stories (Photo 85). A little later, contents in the third story were ignited by sparks from the outside and were totally damaged. This fire was beyond control before it was discovered, but did not spread downward through open stairs. At Building 33, sparks from the west exposure, which burned in early evening, set fire to black-out curtains in the west wall and to waste paper in the fourth story of the northwest section of the building. Twenty persons were on guard in the building awaiting such an occurrence and the fires were quickly extinguished while in the incipient stage. At Building 59 sparks from the south exposure ignited a few pieces of furniture in the first and third stories and black-out curtains in the first story about 2 hours after the attack. These fires were extinguished by men inside and negligible damage resulted. A few window frames in the east and west walls and 2 or 3 desks in the first story of Building 122 were ignited by radiated heat and sparks from the west and northeast exposures. These fires were extinguished quickly and damage was negligible.

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A. SUMMARY

4. The mean areas of effectiveness (MAE) of the atomic bomb for structural damage about ground zero (GZ) and the radii of the MAE's for the several classes of buildings present were computed to be as follows:

	MAE's in square miles	Radii of MAE's in feet
Multistory, earthquake-resistant	0.03	500
Multistory, steel- and reinforced-concrete frame (including both earthquake- and non-earthquake-resistant construction)	.05	700
1-story, light, steel-frame	3.4	5,500
Multistory, load-bearing, brick-wall	3.6	5,700
1-story, load-bearing, brick-wall	6.0	7,300
Wood-frame industrial-commercial (dimension-timber construction)	8.5	8,700
Wood-frame domestic buildings (wood-pole construction)	9.5	9,200
Residential construction	6.0	7,300

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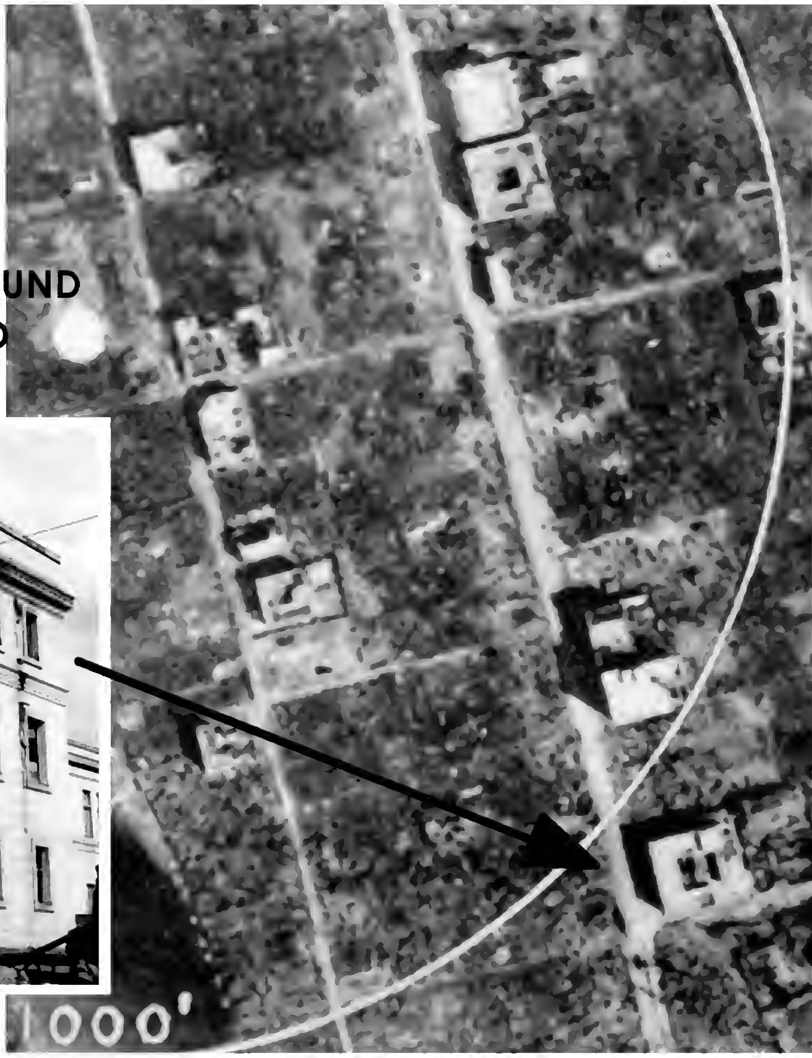
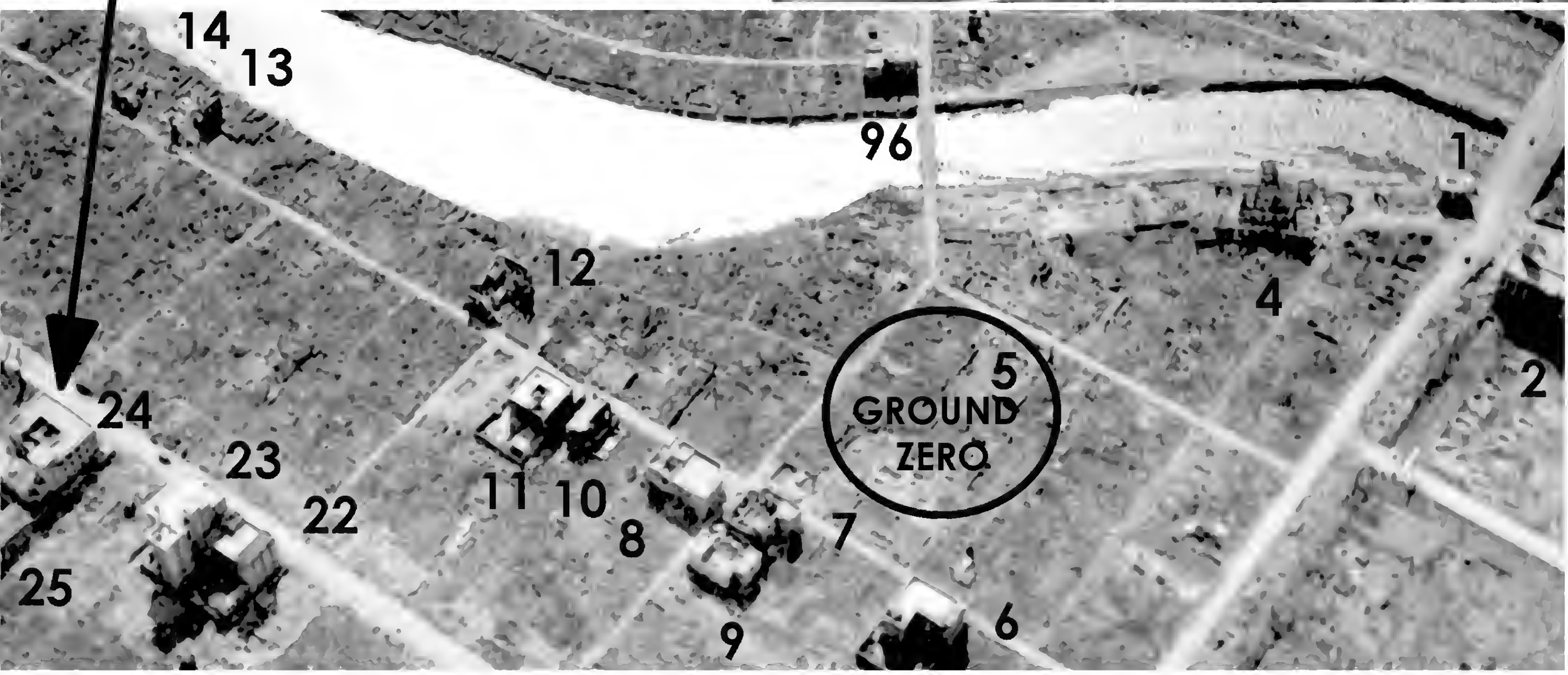
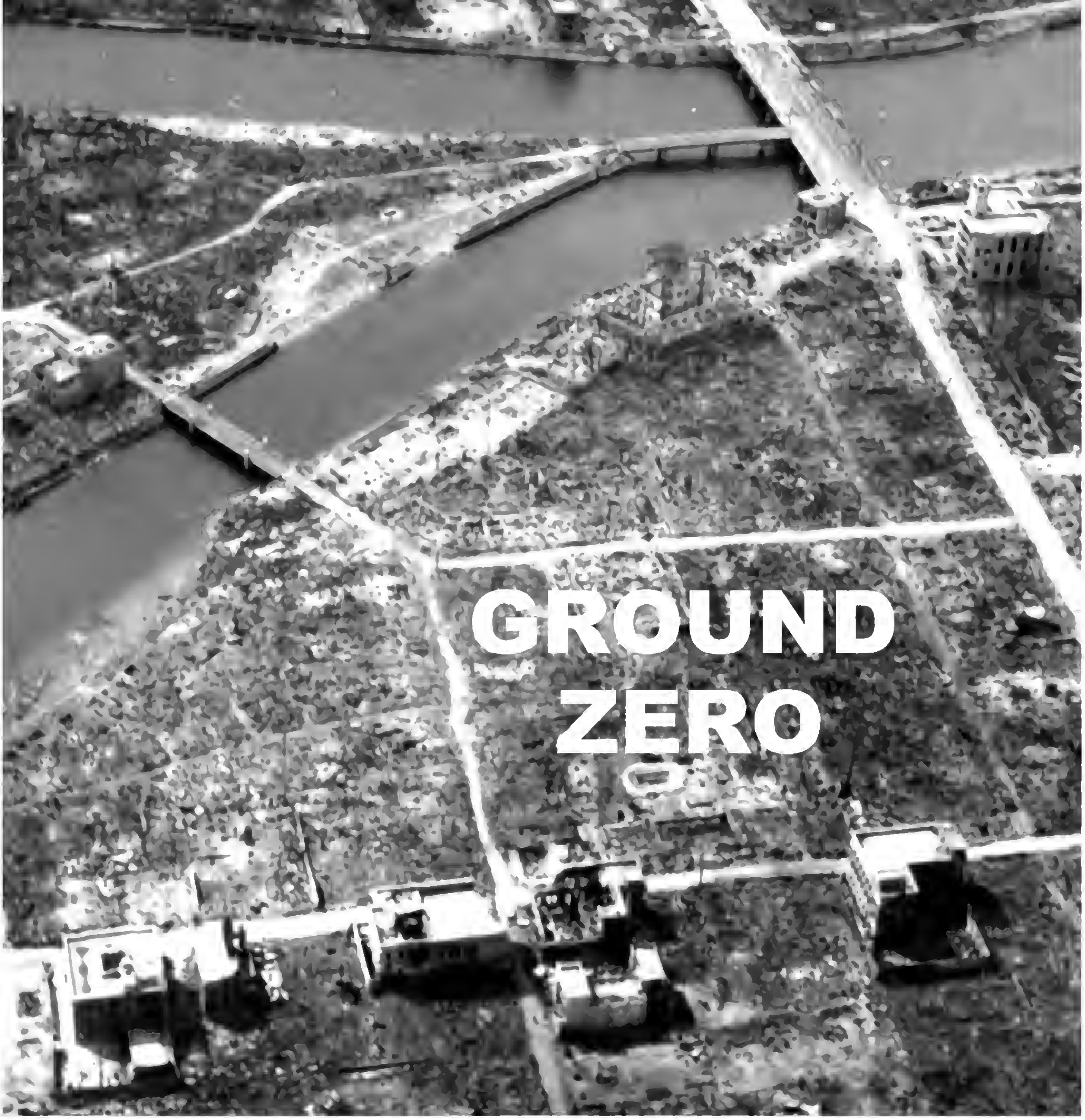
Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.
REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.



U.S. Strategic Bombing Survey report 92





Concrete bridges and buildings survive near Hiroshima's ground zero

NAGASAKI SHELTERS. Tunnel shelters in the hillside, such as the ones pictured (very close to ground zero), protected the few occupants from blast, heat, and radiation.

Building No.: 26. Coordinates: 5H. Distance from (GZ): 2,300, (AZ): 3,000.

NAME: Chugoku Electric Co.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: 5 and basement and penthouse JTG class: E1.

Walls: Reinforced concrete (12-inch).

REMARKS: Fire throughout building except in 60 percent of basement (no fire in basement of west section and about 25 percent of east section). Man who was in third story stated that he saw cotton blackout curtains in west wall and thin paper on desks catch fire from flash of bomb. Fire was reported to have been in all stories 5 minutes after bomb.

Building No.: 40. Coordinates: 5H. Distance from (GZ): 2,500, (AZ): 3,200.

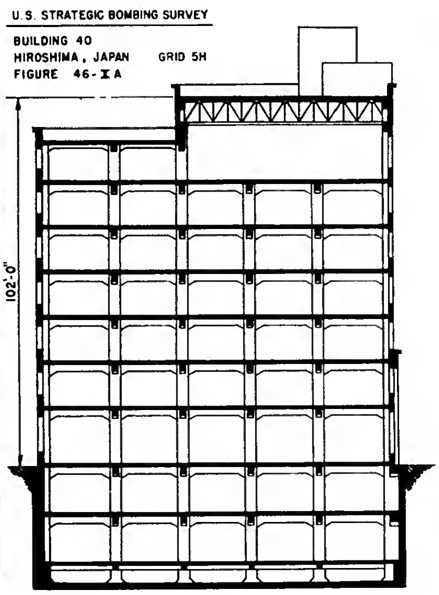
NAME: Fukuya Department Store.

CONSTRUCTION AND DESIGN:

Type: Reinforced-concrete frame.

Walls: 8-inch reinforced concrete—large windows.

REMARKS: Three persons who were questioned individually stated that this building was afire immediately or within 20 minutes after the bomb. One man who was in the building at the time stated that cotton blackout curtains in the west wall were smouldering immediately after the bomb. The entire building was afire at 1000 hours.



Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.

NAME: Bank of Japan, Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame (steel core).

Walls: Reinforced concrete (12-inch) and stone (6-inch).

Floors: Reinforced concrete.

Framing: Reinforced concrete.

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

Building No.: 33. Coordinates: 6H. Distance from (GZ): 5,300, (AZ): 5,600.

NAME: Hiroshima Postal Savings Bureau.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: 4 and basement. JTG class: E1.

Roof: Reinforced concrete, tile finish.

Partitions: Reinforced concrete.

Walls: Reinforced concrete, tile finish.

REMARKS: Sparks from west exposure ignited cotton black-out curtains in west wall at 2000 hours and waste paper in fourth story of northwest section at 2100 hours. Fires were extinguished with water buckets by 20 fire guards who were stationed inside. Fire damage to contents was negligible. Paper records stored in wood and steel racks in northeast section of building were exposed to direct radiated heat from bomb but did not catch fire.

Building No.: 86. Coordinates: 5G. Distance from (GZ): 2,000, (AZ): 2,800.

NAME: Kōkō Private Grammar School.

CONSTRUCTION AND DESIGN

Type: Reinforced concrete.

Number of stories: Three. JTG class: E1.

Roof: Reinforced-concrete slab.

Partitions: 9-inch brick and 6-inch reinforced concrete.

Walls: Reinforced concrete (8–10 inches).

Building No.: 49. Coordinates: 5I. Distance from (GZ): 3,000, (AZ): 3,600.

Name: Chūgoku Newspaper.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of Stories: 7 and penthouse. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: Reinforced concrete—lath and plaster.

Walls: 7-inch reinforced concrete—large windows.

REMARKS: Man who was in building at time of bomb stated fire broke out in third and fourth stories immediately after bomb flash. Head bookkeeper in bank in Building 51 stated that there was fire in third story of Building 49, 10 minutes after bomb flash.

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Walls: 8-inch reinforced concrete monolithic—medium window.

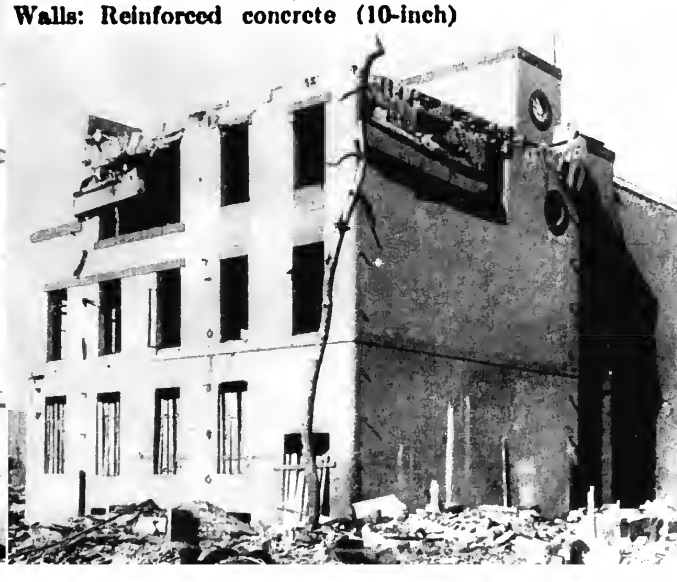
EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.

Building No.: 96. Coordinates: G5. Distance from (GZ): 400 (AZ): 2,000.

NAME: Taisho Clothing Store.

Walls: Reinforced concrete (10-inch)



Building No.: 10 Coordinates: 5H. Distance from (GZ): 600, (AZ): 2,100.

NAME: Nippon Life Insurance Co., Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Load-bearing brick wall.

Number of stories: See drawing. JTG class: F2.

Roof: Reinforced-concrete slab 6 inch (¼-inch bars 6-inch oc by 12 inch oc).

Building No.: 18. Coordinates: 5H. Distance from (GZ): 1,000, (AZ): 2,200.

NAME: Geibi Bank Co., Hiroshima Branch.

CONSTRUCTION AND DESIGN

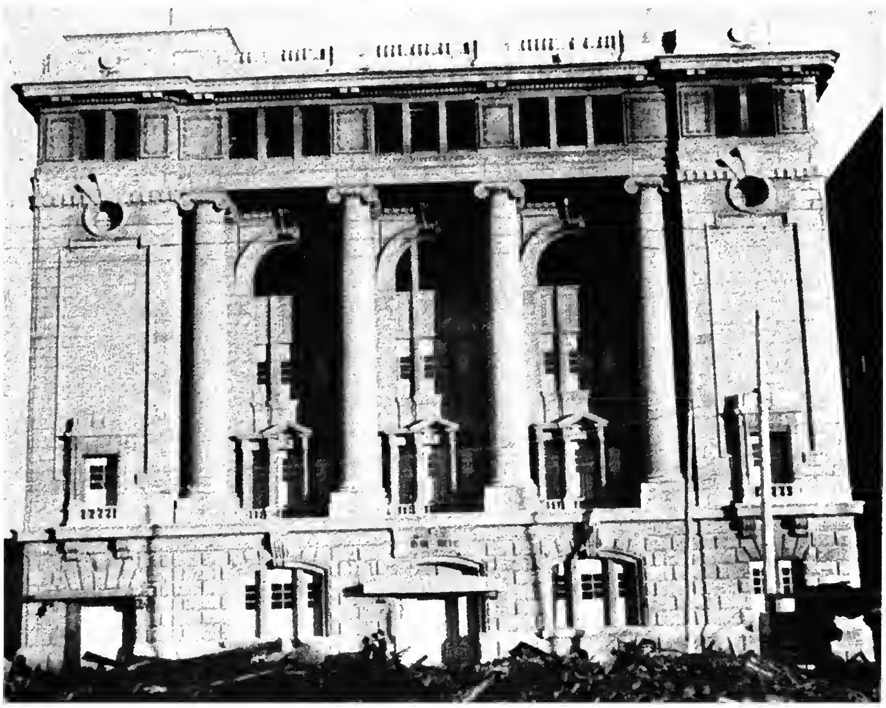
Type: Reinforced-concrete frame.

Number of stories: 5 and ½ basement. JTG class: E1.

Roof: Reinforced-concrete slab (metal pan).

Partitions: Reinforced-concrete (5-inch). Wood lath and plaster in rear addition.

Walls: Reinforced concrete (10-inch).



Building No.: 23. Coordinates: 5H. Distance from (GZ): 1,200; (AZ); 2,300.

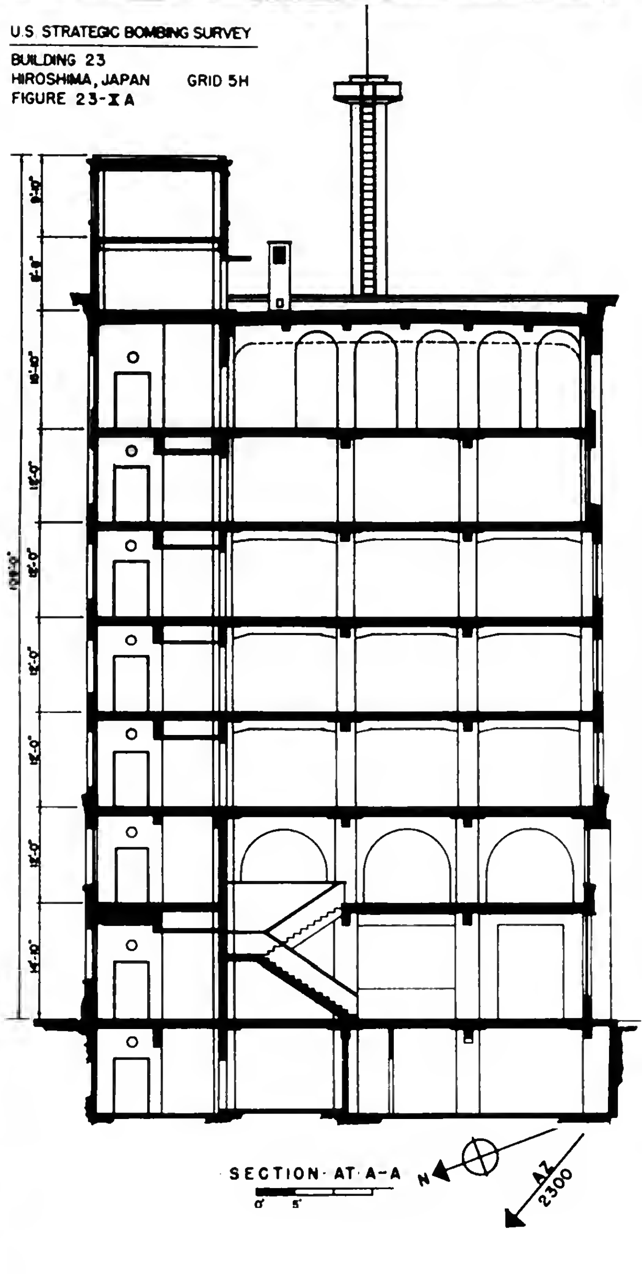
NAME: Fukoku Building.

CONSTRUCTION AND DESIGN

Type: Steel core reinforced-concrete frame.

Number of stories: 7 and basement. JTG class: E1.

Roof: Reinforced-concrete beam and slab (steel core).



U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

Building No.: 5. **Coordinates:** 5H. **Distance from (GZ):** 100, (AZ): 2,000.
NAME: Shima Surgical Hospital.
CONSTRUCTION AND DESIGN
Type: Bearing wall.
Number of stories: 1. **JTG class:** A 2-3.
Roof: Tile over wood on wood truss.
Partitions: Plaster on wood lath and studs.
Walls: Brick-bearing, 18 inches.

Building No.: 6. **Coordinates:** 5H. **Distance from (GZ):** 600, (AZ): 2,100.
NAME: Chiyoda Life Insurance Co., Chugoku branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame.
Number of stories: Three and basement. **JTG class:** E1.
Roof: Reinforced-concrete beam and slab-tile covered.
Partitions: Reinforced-concrete, major—metal lath and plaster, minor.
Walls: Reinforced-concrete panels, 10 inches. Reinforced-concrete granite facing.

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

Sheet No. 1

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.
NAME: Bank of Japan, Hiroshima branch.
CONSTRUCTION AND DESIGN
Type: Reinforced-concrete frame (steel core).
Number of Stories: 3 and basement. JTG class: E1.
Roof: Reinforced-concrete beam and slab.
Partitions: Reinforced concrete and wood lath.
Walls: Reinforced concrete (12-inch) and stone (6-inch).
Floors: Reinforced concrete.
Framing: Reinforced concrete.
Window and door frames: Metal (exterior) wood (interior). Ceilings: Plaster on concrete.
Condition, workmanship, and materials: Excellent.
Compare with usual United States buildings: Much stronger—steel core construction.
OCCUPANCY: Bank.
CONTENTS: Bank and office equipment furnishings.
DAMAGE to building: Only minor damage—top story burned out, partitions, sash, trim blown out in two lower stories.
Cause: Fire.
To Contents: Destroyed in third story—moderate debris and blast damage in first and second stories, none in basement.
Cause: Fire and debris (about equally).
TOTAL FLOOR AREA (square feet): 32,800. Structural damage: —. Superficial damage:
FRACTION OF DAMAGE: Building structural: —. Superficial: —. Contents: 30 percent.
REMARKS: Glass removed from skylight (20 by 20 feet) and light steel-frame structure and roof covered with 12 to 18 inches of sand and cinders.

Note.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

Sheet No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 24. Fire classification: R.
WALL OPENINGS: Shutters: Steel rollers.
Shut: Part.
Effect of blast: Blown in.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Part	Steel rollers	No	None—doors open.
Elevators:	Yes	Metal and W. G.	No	Bent.

EXPOSURE:

Location	Distance	Firebreak Clearance	Class	Fire Burned	Remarks
N	25′	No	C	Yes	14-foot concrete wall between.
E	25′	No	R	Yes	Building 25 (14-foot wall between).
S	—	No	—	—	No exposure.
W	125′	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.
VERTICAL FIRE SPREAD: No.
EXTENT OF FIRE: Total floor area: 32,800 square feet. Floor area burned: 5,200 square feet; 16 percent (after blast damage).

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

Sheet No. 1

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: See sketch. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: 7-inch reinforced concrete.

Walls: 8-inch reinforced concrete monolithic—medium window.

Floors: Reinforced-concrete beam and slab—parquet and tile.

Framing: Reinforced-concrete beam and slab.

Window and door frames: Steel. Ceilings: Sheet metal on wood framing.

Condition, workmanship and materials: Good.

Compare with usual United States buildings: Appreciably stronger than United States design.

OCCUPANCY: Police station (office).

CONTENTS: Office equipment.

DAMAGE to building: Minor damage only—sash blown out and hung ceilings partially stripped.

Cause: Blast.

To contents: Slight damage to contents from blast and debris.

Cause: Blast.

TOTAL FLOOR AREA (square feet): 16,200. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building. Structural: Superficial: Contents: 10 percent.

REMARKS:

Note.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

Sheet No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 59. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers in east wall and third story of south and west walls (wired glass in all windows).

Effect of blast: Blown in at west wall, bent at south wall.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Yes	Metal	No	Bent slightly.
Elevators:				

EXPOSURE:

Location	Distance	Firebreak Clearance	Fire Class	Burned	Remarks
N	150′	Yes	C	Yes	
E	60′	Yes	C	Yes	
S	30′	Partial 100′	C	Yes	All exposures burned.
W	60′	Yes	C	Yes	

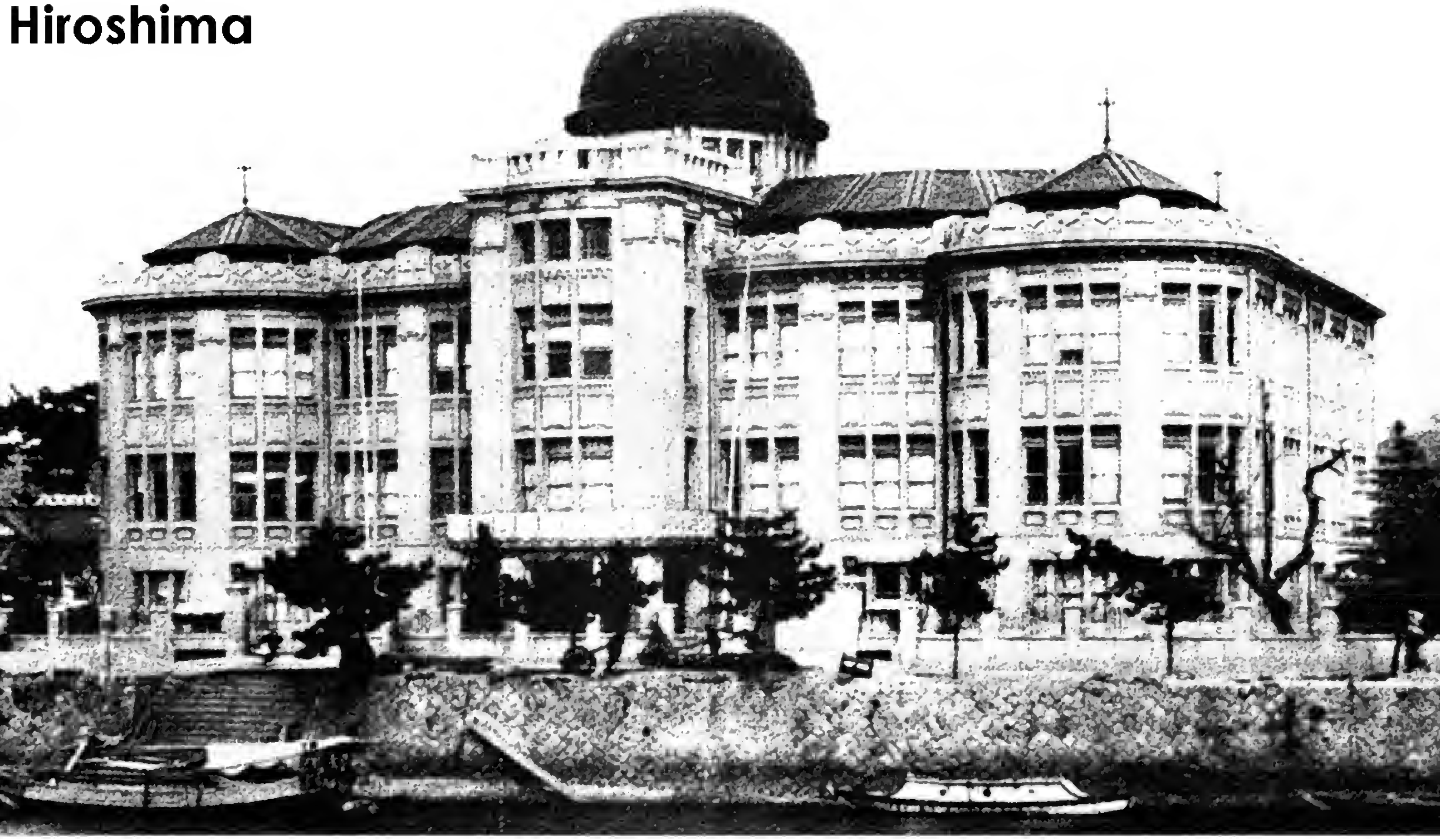
PROBABLE CAUSE OF FIRE: Fire spread from exposures.

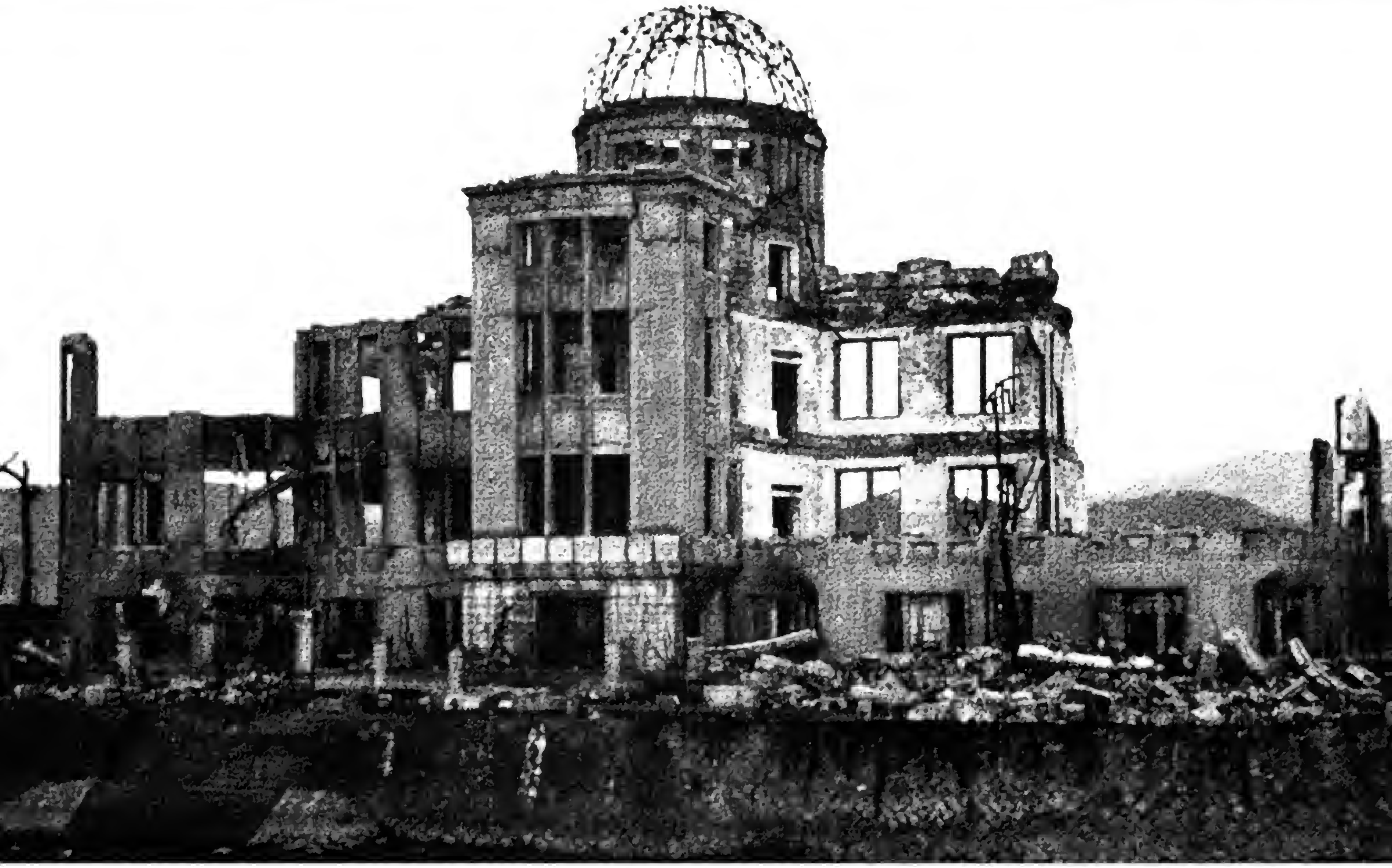
VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.

Hiroshima





Commercial Museum ('300 meters) before and after

BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA

GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

Bank of Japan: USSBS Building 24, 1300 ft from GZ
Geibi Bank Co: USSBS Building 59, 4100 ft from GZ
(Table 5 of USSBS report 92 Hiroshima, v2.)

In both, survivors extinguished fire with water buckets.

(Ref: Panel 26 of the "DCPA Attack Environment Manual", Chapter 3.)

ADA038738

Secondary Fires

Secondary fires are those that result from airblast damage. Their causes include overturned gas appliances, broken gas lines, and electrical short-circuits. McAuliffe and Moll (Reference 1) studied secondary fires resulting from the atomic attacks on Hiroshima and Nagasaki and compared their results with data from conventional bombings, explosive disasters, earthquakes, and tornadoes. Their major conclusion was that secondary ignitions occur with an overall average frequency of 0.006 for each 1000 square feet of floor space, provided airblast peak overpressure is at least 2 psi. The frequency of secondary ignitions appears to be relatively insensitive to higher overpressures.

Based on surveys of Hiroshima and Nagasaki buildings.

FREQUENCY OF SECONDARY IGNITIONS AS A FUNCTION OF BUILDING TYPE

Type of Structure	Frequency of Secondary Ignitions (for each 1,000 square feet of floor area)
Wood	0.019
Brick	0.017
Steel	0.004
Concrete	0.002

MULTIPLYING FACTOR FOR TYPES OF BUILDING OCCUPANCIES

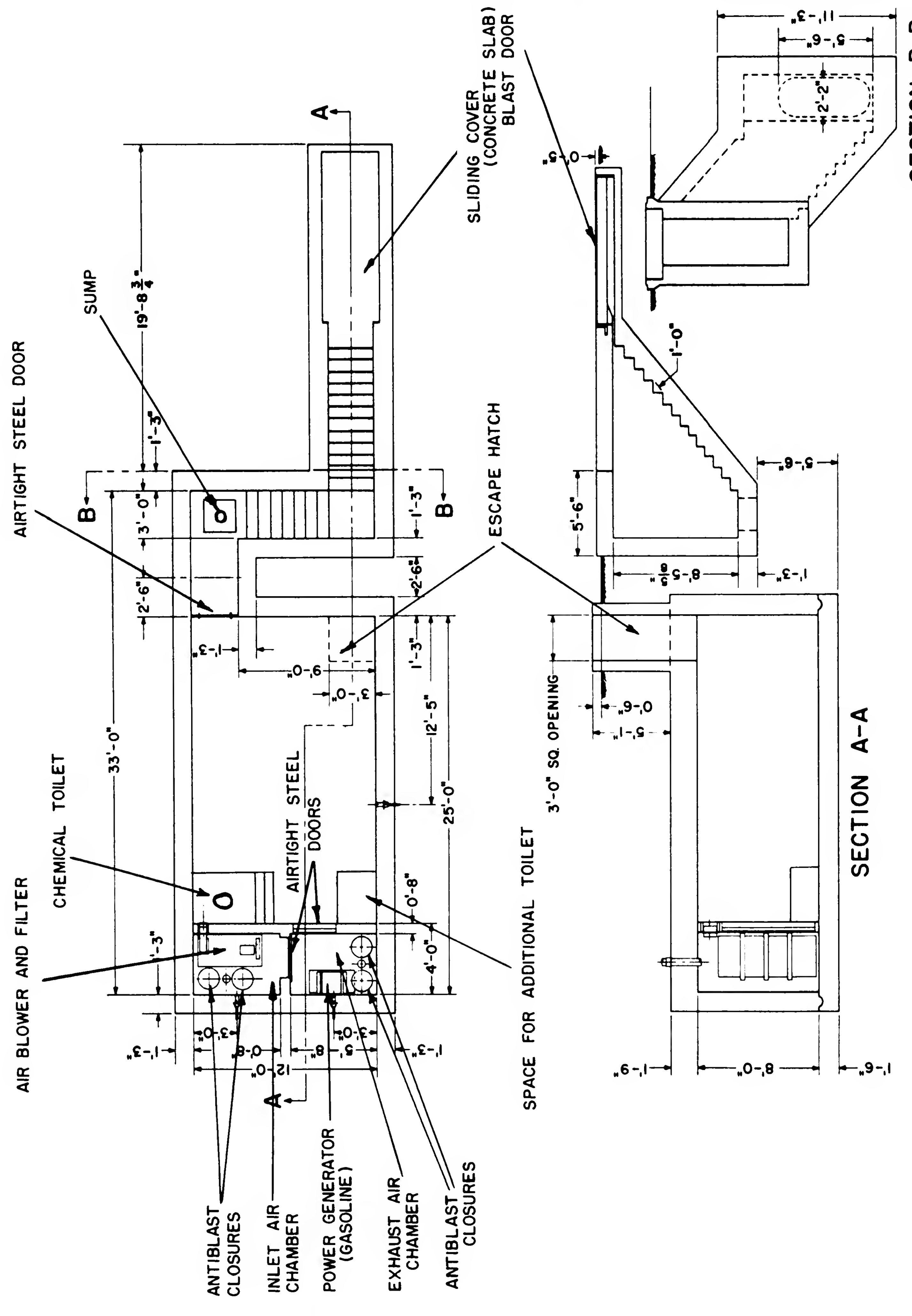
Type of Occupancy	Multiplying Factor
Public	0.4
Mercantile	0.5
Residential	0.5
Manufacturing	1.0
Miscellaneous	10.0

MULTIPLYING FACTOR FOR TIME OF DAY

Time of Day	Multiplying Factor
Night	0.5
Day (other than mealtimes)	1.0
Mealtimes	2.0

1 . Secondary Ignitions in Nuclear Attack, J. McAuliffe and K. Moll, Stanford Research Institute, Menlo Park, California 94025, SRI Project 5106 (AD 625173), July 1965.

Type 4 reinforced concrete shelter (Nevada bomb test)
Fig. 12.54 in Glasstone Effects of Nuclear Weapons, 1957



Sectional plan and section of underground personnel shelter

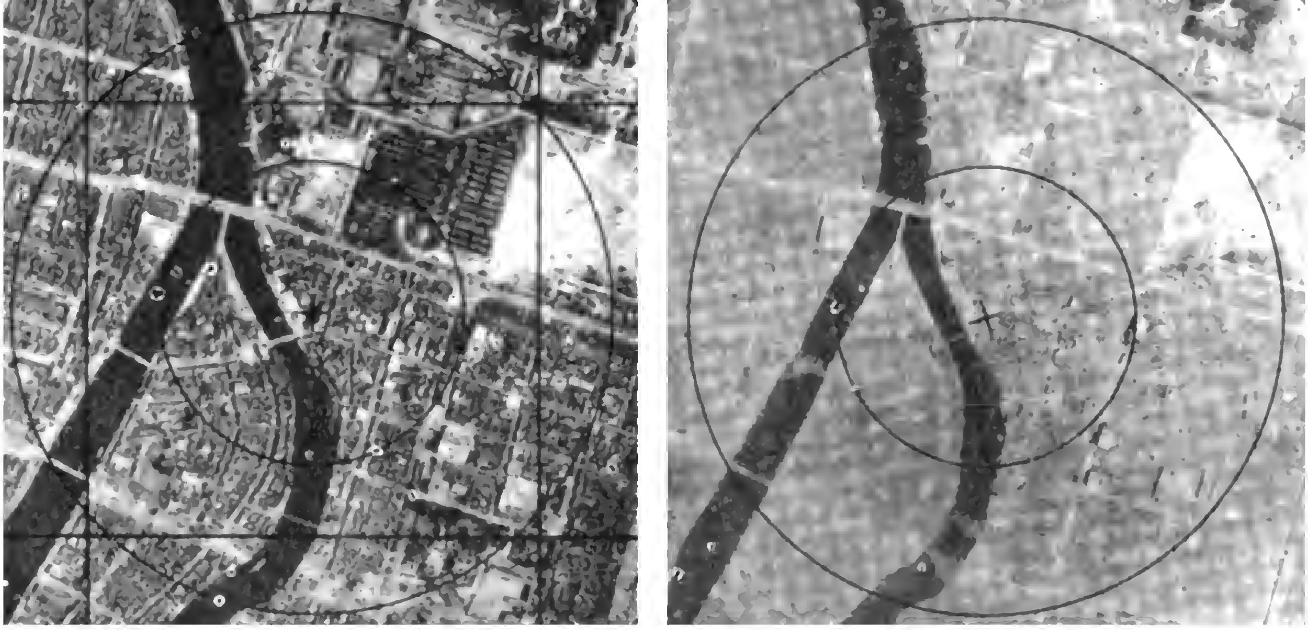
THE UNITED STATES STRATEGIC BOMBING SURVEY

The Effects of Atomic Bombs on Hiroshima and Nagasaki

CHAIRMAN'S OFFICE

30 June 1946

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1946



HIROSHIMA before and after bombing. Area around ground zero. 1,000 foot circles.

A. A. F. Photos

7

Above: surviving buildings are air-brushed out of photo of Hiroshima 1946 USSBS openly published Hiroshima and Nagasaki report, page 7

Below: secret BEFORE and AFTER Hiroshima photos

Hiroshima BEFORE (USSBS photo)

Modern concrete buildings AFTER.

Small wooden, overcrowded houses have burned down after blast overturned stoves (8:15 am, breakfast time).

II. THE EFFECTS OF THE ATOMIC BOMBINGS

A. THE ATTACKS AND DAMAGE

1. *The attacks.*—A single atomic bomb, the first weapon of its type ever used against a target, exploded over the city of Hiroshima at 0815 on the morning of 6 August 1945. Most of the industrial workers had already reported to work, but many workers were enroute and nearly all the school children and some industrial employees were at work in the open on the program of building removal to provide firebreaks and disperse valuables to the country. The attack came 45 minutes after the "all clear" had been sounded from a previous alert. Because of the lack of warning and the populace's indifference to small groups of planes, the explosion came as an almost complete surprise, and the people had not taken shelter. Many were caught in the open, and most of the rest in flimsily constructed homes or commercial establishments.

At Nagasaki, 3 days later, the city was scarcely more prepared, though vague references to the Hiroshima disaster had appeared in the newspaper of 8 August. From the Nagasaki Prefectural Report on the bombing, something of the shock of the explosion can be inferred:

> The day was clear with not very much wind—an ordinary midsummer's day. The strain of continuous air attack on the city's population and the severity of the summer had vitiated enthusiastic air raid precautions. Previously, a general alert had been sounded at 0748, with a raid alert at 0750; this was canceled at 0830, and the alertness of the people was dissipated by a great feeling of relief.

The city remained on the warning alert, but when two B-29's were again sighted coming in the raid signal was not given immediately; the bomb was dropped at 1102 and the raid signal was given a few minutes later, at 1109. Thus only about 400 people were in the city's tunnel shelters, which were adequate for about 30 percent of the population.

2. *Hiroshima.*

If there were, as seems probable, about 245,000 people in the city at the time of the attack, the density in the congested area must have been about 35,000 per square mile. Five completed evacuation programs and a sixth then in progress had reduced the population from its wartime peak of 380,000.

In Hiroshima (and in Nagasaki also) the dwellings were of wood construction; about one-half were one story and the remainder either one and one-half or two stories. The roof coverings were mostly hard-burnt black tile. There were no masonry division walls, and large groups of dwellings clustered together. The type of construction, coupled with antiquated fire-fighting equipment and inadequately trained personnel, afforded even in peacetime a high possibility of conflagration. Many wood-framed industrial buildings were of poor construction by American standards. The principal points of weakness were the extremely small tenons, the inadequate tension joints, and the inadequate or poorly designed lateral bracings. Reinforced concrete framed buildings showed a striking lack of uniformity in design and in quality of materials. Some of the construction details (reinforcing rod splices, for example) were often poor, and much of the concrete was definitely weak; thus some reinforced concrete buildings collapsed and suffered structural damage when within 2,000 feet of ground zero, and some internal wall paneling was demolished even up to 3,800 feet. (For convenience, the term "ground zero" will be used to designate the point on the ground directly beneath the point of detonation, or "air zero.")

Hiroshima's industrial production could have resumed normal operation within 30 days of the attack had the war continued.

official Japanese figures summed up the building destruction at 62,000 out of a total of 90,000 buildings in the urban area, or 69 percent. An additional 6,000 or 6.6 percent were severely damaged, and most of the others showed glass breakage or disturbance of roof tile. These figures show the magnitude of the problem facing the survivors.

Despite the absence of sanitation measures, no epidemics are reported to have broken out.

9

Nagasaki

Because parts of the city were protected by hills, more than one-half of the residential units escaped serious damage. Of the 52,000 residential units in the city on 1 August, 14,146 or 27.2 percent were completely destroyed (by Japanese count) (11,494 of these were burned); 5,441 or 10.5 percent were half-burned or destroyed; many of the remaining units suffered superficial or minor damage.

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Because of the brief duration of the flash wave and the shielding effects of almost any objects—leaves and clothing as well as buildings—there were many interesting cases of protection. The radiant heat came in a direct line like light, so that the area burned corresponded to this directed exposure. Persons whose sides were toward the explosion often showed definite burns of both sides of the back while the hollow of the back escaped. People in buildings or houses were apparently burned only if directly exposed through the windows. The most striking instance was that of a man writing before a window. His hands were seriously burned but his exposed face and neck suffered only slight burns due to the angle of entry of the radiant heat through the window.

Flash burns were largely confined to exposed areas of the body, but on occasion would occur through varying thicknesses of clothing. Generally speaking, the thicker the clothing the more likely it was to give complete protection against flash burns.

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A large percentage of the cases died of secondary disease, such as septic bronchopneumonia or tuberculosis, as a result of lowered resistance. Deaths from radiation began about a week after exposure and reached a peak in 3 to 4 weeks. They had practically ceased to occur after 7 to 8 weeks.

19

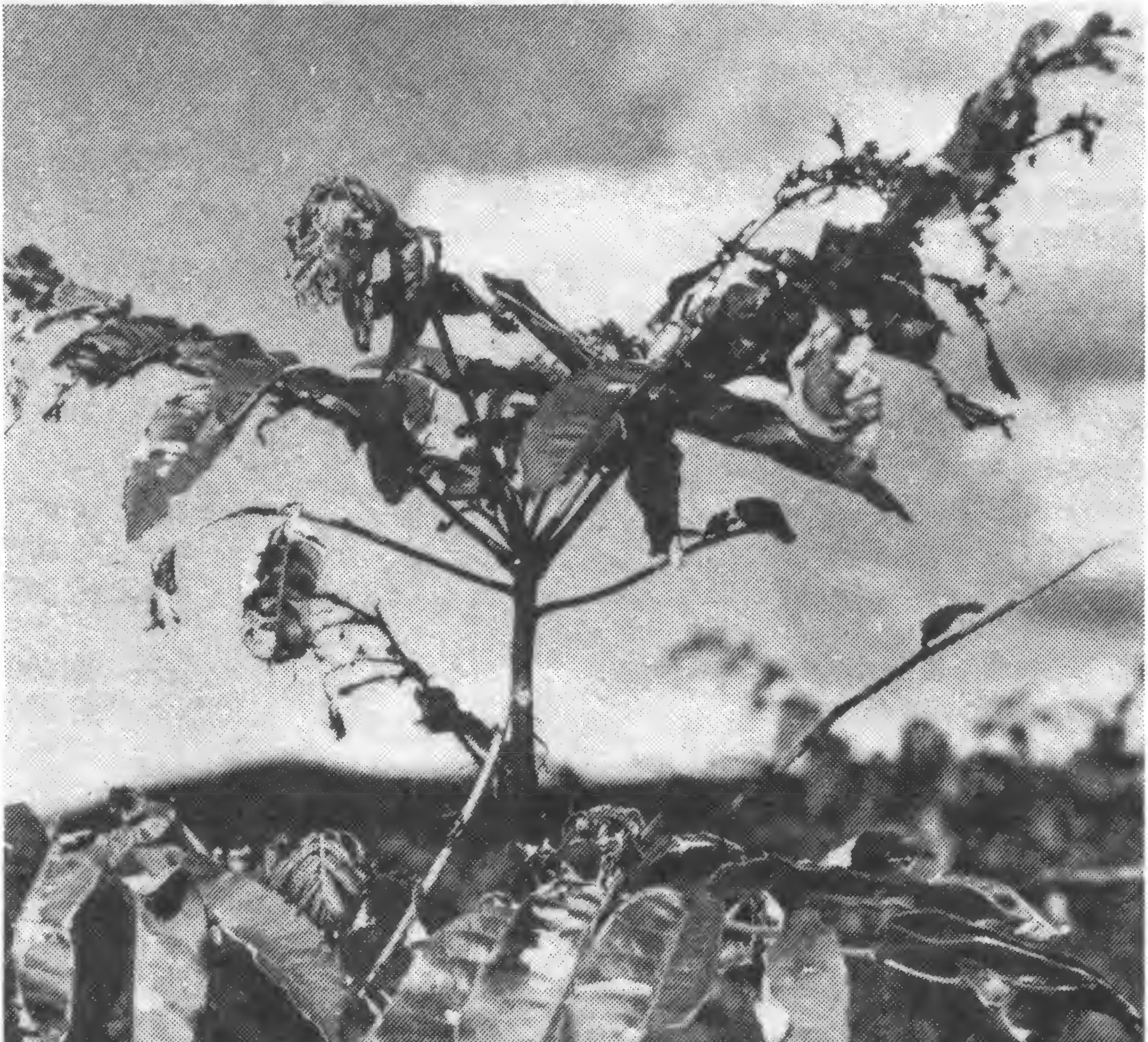
The flash heat was intense enough to cause fires, despite the distance of the fireball from the ground. Clothing ignited, though it could be quickly beaten out, telephone poles charred, thatched roofs of houses caught fire. In Hiroshima, the explosion started hundreds of fires almost simultaneously, the most distant of which was found 13,700 feet from ground zero; this, however, probably started when a building with a thatched roof collapsed onto a hot charcoal fire. Fires were started directly by flash heat in such easily ignitible substances as dark cloth, paper, or dry-rotted wood, within about 3,500 feet of ground zero; white-painted, concrete-faced or cement-stuccoed structures reflected the heat and did not ignite. A cedar bark roof and the top of a dry-rotted wooden platform 5,200 feet west of ground zero, were reported to have been ignited by the bomb flash. The majority of initial fires in buildings, however, were started by secondary sources (kitchen charcoal fires, electric short-circuits, industrial process fires, etc.).

Serious or third-degree burns were suffered by those directly exposed within 4,500 feet, and occasionally as remote as 7,200 feet. In the immediate area of ground zero, the heat charred corpses beyond recognition.

Clothing as well as buildings afforded considerable protection against the flash. Even a clump of grass or tree leaf was, on occasion, adequate.

The implication clearly is that the duration of the flash was less than the time required for the grass or leaf to shrivel. While an accurate estimate is not possible, the duration could hardly have exceeded a fraction of a second.

25



NEW SHOOTS are appearing on this limb of a chestnut tree, about 2,100 feet south of ground zero at Nagasaki, 2 months after the attack, even though the leaves were burned and withered at the time of the explosion (Japanese photo).

B. WHAT WE CAN DO ABOUT IT

The danger is real—of that, the Survey's findings leave no doubt. Scattered through those findings, at the same time, are the clues to the measures that can be taken to cut down potential losses of lives and property.

---

1. *Shelters.*—The most instructive fact at Nagasaki was the survival, even when near ground zero, of the few hundred people who were properly placed in the tunnel shelters. Carefully built shelters, though unoccupied, stood up well in both cities. Without question, shelters can protect those who get to them against anything but a direct hit. Adequate warning will assure that a maximum number get to shelters.

Analysis of the protection of survivors within a few hundred feet of ground zero shows that shielding is possible even against gamma rays. At Hiroshima, for example, persons in a concrete building 3,600 feet from ground zero showed no clinical effects from gamma radiation, but those protected only by wooden buildings at a similar distance suffered from radiation disease. The necessary thickness varies with the substance and with the distance from the point of detonation. Adequate shelters can be built which will reduce substantially the casualties from radiation.

Men arriving at Hiroshima and Nagasaki have been constantly impressed by the shells of reinforced concrete buildings still rising above the rubble of brick and stone or the ashes of wooden buildings. In most cases gutted by fire or stripped of partitions and interior trim, these buildings have a double lesson for us. They show, first, that it is possible without excessive expense to erect buildings which will satisfactorily protect their contents at distances of about 2,000 feet or more from a bomb of the types so far employed. Construction of such buildings would be similar to earthquake resistant construction, which California experience indicates would cost about 10 percent to 15 percent more than conventional construction. Even against more powerful bombs or against near misses, such construction would diminish damage.

As defensive weapons, atomic bombs are useful primarily as warnings, as threats of retaliation which will restrain a potential aggressor from their use as from the use of poison gas or biological warfare. The mission of active defense, as of passive defense, is thus to prevent the surprise use of the atomic bomb from being decisive. A wise military establishment will make sure—by dispersal, concealment, protection, and constant readiness of its forces—that no single blow or series of blows from an enemy can cripple its ability to strike back in the same way or to repel accompanying attacks from other air, ground, or sea forces. The measures to enable this unrelaxing state of readiness are not new; only their urgency is increased. Particularly is this true of the intelligence activities on which informed decisions and timely actions depend.

The need for research is not limited to atomic energy itself, but is equally important in propellants, detection devices, and other techniques of countering and of delivering atomic weapons.

---

5. *Conclusion.*—One further measure of safety must accompany the others. To avoid destruction, the surest way is to avoid war. This was the Survey's recommendation after viewing the rubble of German cities, and it holds equally true whether one remembers the ashes of Hiroshima or considers the vulnerability of American cities.

Our national policy has consistently had as one of its basic principles the maintenance of peace. Based on our ideals of justice and of peaceful development of our resources, this disinterested policy has been reinforced by our clear lack of anything to gain from war—even in victory. No more forceful arguments for peace and for the international machinery of peace than the sight of the devastation of Hiroshima and Nagasaki have ever been devised. As the developer and exploiter of this ominous weapon, our nation has a responsibility, which no American should shirk, to lead in establishing and implementing the international guarantees and controls which will prevent its future use.

Head for the basement as soon as the siren sounds and remain as close as possible to heavy, supporting columns to avoid the danger of collapsing beams. Stay away from all entrances and all windows. If there are heavy steel doors and shutters, close them.

The British government recommends construction of raid shelters on the order of the Anderson-type, built outside many British homes during the Hitler blitz. These were steel arches, six feet high and four-and-a-half feet wide, half buried in the ground. Civil defense authorities assert that if three feet of earth were piled above the arch, the shelter could protect all inside from the four main causes of death and injury.

Don't be in a rush to emerge from your hideout—stay there until you have been assured the bomb will not be dropped, long enough for radiation outside to wear off.

IF YOU ARE TRAPPED ON THE TOP FLOOR OF A BUILDING . . .
and descent to the basement is prevented by jammed elevators and stairs, don't join the mob battling to get down. Proceed to a point as close to the center of the building as possible and lie against a wall or strong supporting column, out of line of the windows. Or crawl under a table, sofa or desk which would provide protection against flying glass.

IF YOU ARE WALKING ON THE STREET . . .
get out of the open. Remember that flash and flame burns killed 50 per cent of the 106,000 persons who died in the atomic attack on Hiroshima and Nagasaki and accounted for 75 per cent of all casualties. The bomb's heat rays travel in a straight line—so all you have to do is get inside.

Head for the nearest official shelter. If there aren't any, a subway—the deeper the better—will do as well.

Target area at Hiroshima was completely leveled except for a few reinforced concrete building frames. That's why American builders of A-bomb shelters concentrate on the use of thick concrete walls.

The U. S. Strategic Bombing Survey No. 5 undertaken by the U. S. Air Force, states flatly: "The most instructive fact at Nagasaki was the survival of the few hundred people who were properly placed in tunnel shelters. Without question, shelters can protect those who get to them against anything but a direct hit."

The best protection from shock, radiation and heat is reinforced concrete; almost as good is closely packed earth. The thickness required to protect you fully depends, obviously, on the distance from the blast. How much protection and at what distances? Well many other factors influence the effect of an atomic blast, including height of the burst, direction of the blast and types of buildings in its path. The government handbook, The Effects of Atomic Weapons, estimates that at a half-mile from the explosion, a 12-inch reinforced concrete wall inside a building would provide enough protection.

DISASTER AND RECOVERY: A HISTORICAL SURVEY

Jack Hirshleifer

MEMORANDUM
RM-3079-PR
1963

AD 403337

The RAND Corporation
SANTA MONICA • CALIFORNIA

As at Hamburg, people proved tougher than structures. Almost 70 per cent of the buildings in Hiroshima were destroyed, compared with around 30 per cent of population.[1]

The Research Department of the Hiroshima Municipal Office is reported to have estimated the population in the city as 407,000, in Hiroshima (Hiroshima Publishing Company, 1949).

[1]These proportions are the estimates used by the U.S. Strategic Bombing Survey report. The Hiroshima Municipal Office calculations show an even greater disparity, reporting 22 per cent of population killed and missing but some 89 per cent of buildings as destroyed or needing reconstruction (Hiroshima).

On August 7 power was generally restored to surviving areas, and through railroad service commenced on August 8. Telephone service started on August 15. Hiroshima was also not a dead city. The U.S. Strategic Bombing Survey reported that plants responsible for three-fourths of the city's industrial production could have resumed normal operations within 30 days (the newer and larger plants in Hiroshima were on the outskirts of the city, and both physical premises and personnel generally survived).[1] By mid-1949 the population had grown to over 300,000 once more, and 70 per cent of the destroyed buildings had been reconstructed.[2]

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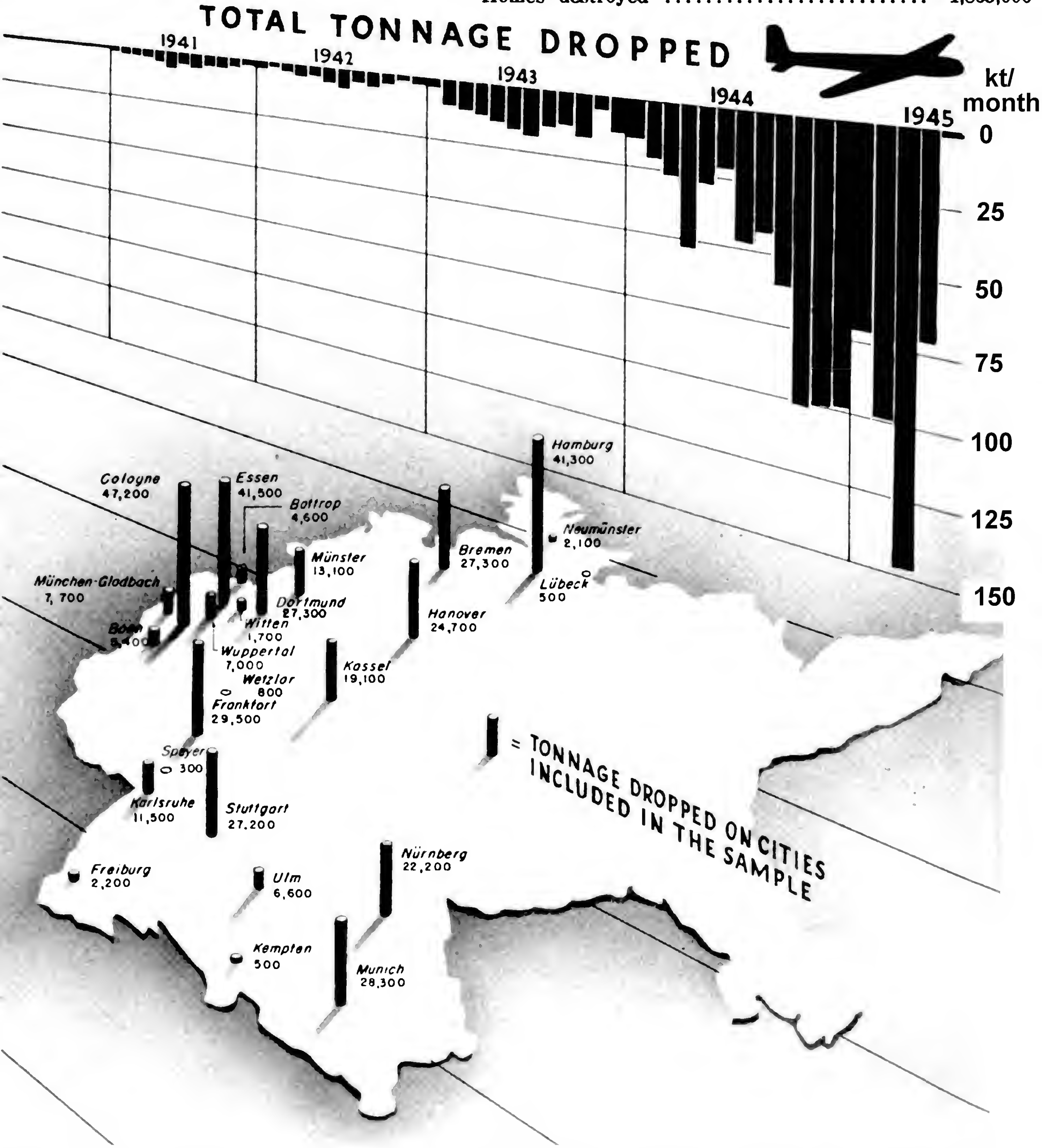
[1]USSBS, "The Effects of Atomic Bombs at Hiroshima and Nagasaki," p. 8.

[2]Hiroshima.

BOMBING ATTACKS ON GERMANY

TABLE 1.—*Physical effects of bombing*

Killed	305,000
Wounded	780,000
Homes destroyed	1,865,000



Source: U.S. Strategic Bombing Survey, "The Effects of Strategic Bombing on German Morale, Volume 1", May 1947.

Over-all Report (European War). 109 pp. STRATEGIC BOMBING SURVEY

This volume recounts the history of the build-up of air power, showing the great increase in 1945. The results of attack on selected major industries in Germany are also considered. The report concludes that attrition caused the downfall of economy, especially as it affected transportation and oil.

LOGISTICS TARGETTED

Summary Report (European War). 18 pp. STRATEGIC BOMBING SURVEY

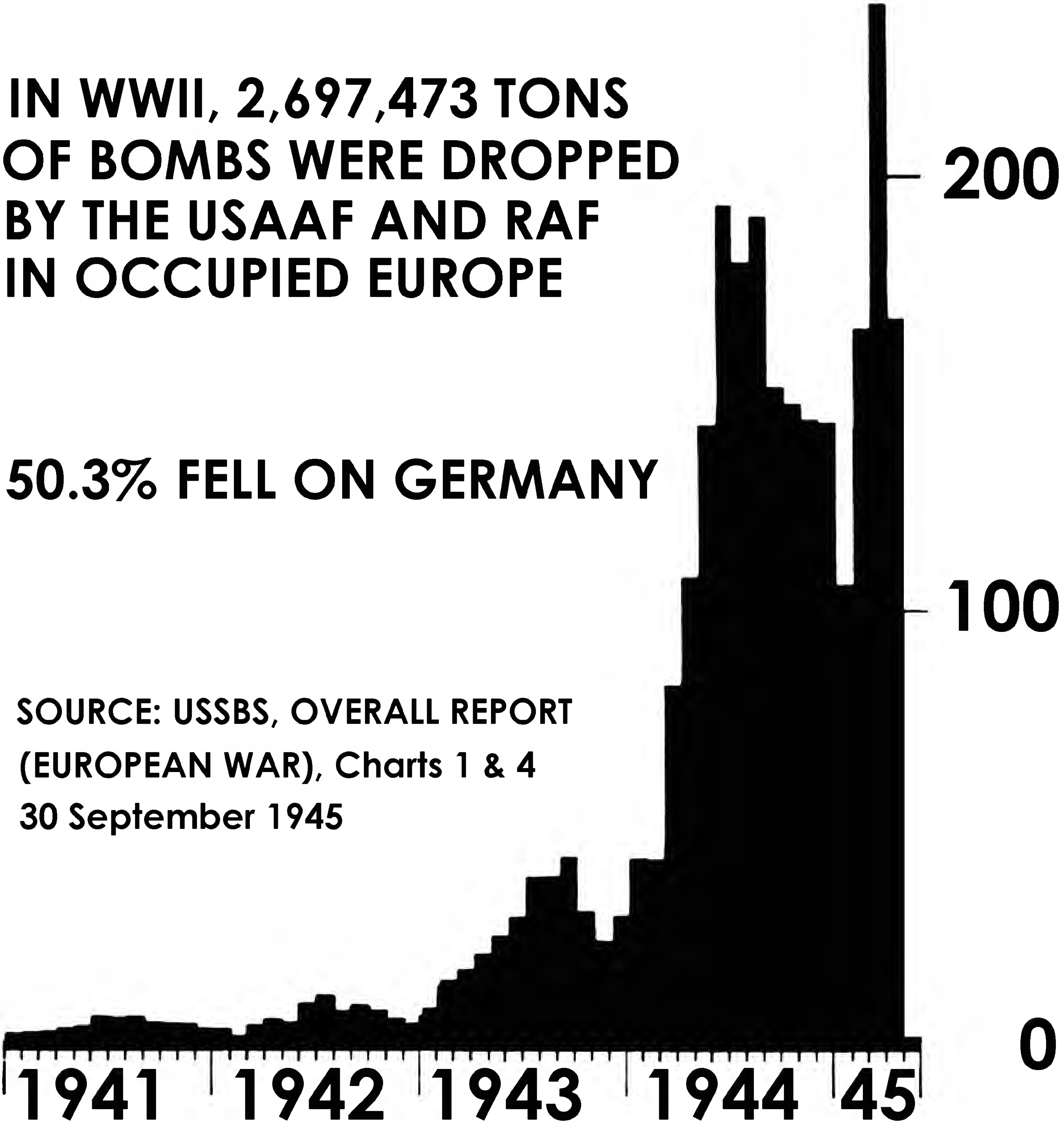
Germany planned a quick war; the Allies planned a long war and started a systematic attack on German industry. The British concentrated on area raids; the United States, on precision bombing. Ball bearings, aircraft, oil, steel, and transportation were attacked in order. The attack on transportation was the decisive blow that completely disorganized the German economy. Civilians withstood bombing fairly well, and the recuperation of German industry was surprising.

CONVENTIONAL KILOTONS/MONTH DROPPED IN WWII BY ALLIES

IN WWII, 2,697,473 TONS OF BOMBS WERE DROPPED BY THE USAAF AND RAF IN OCCUPIED EUROPE

50.3% FELL ON GERMANY

SOURCE: USSBS, OVERALL REPORT (EUROPEAN WAR), Charts 1 & 4
30 September 1945



CIVIL DEFENCE

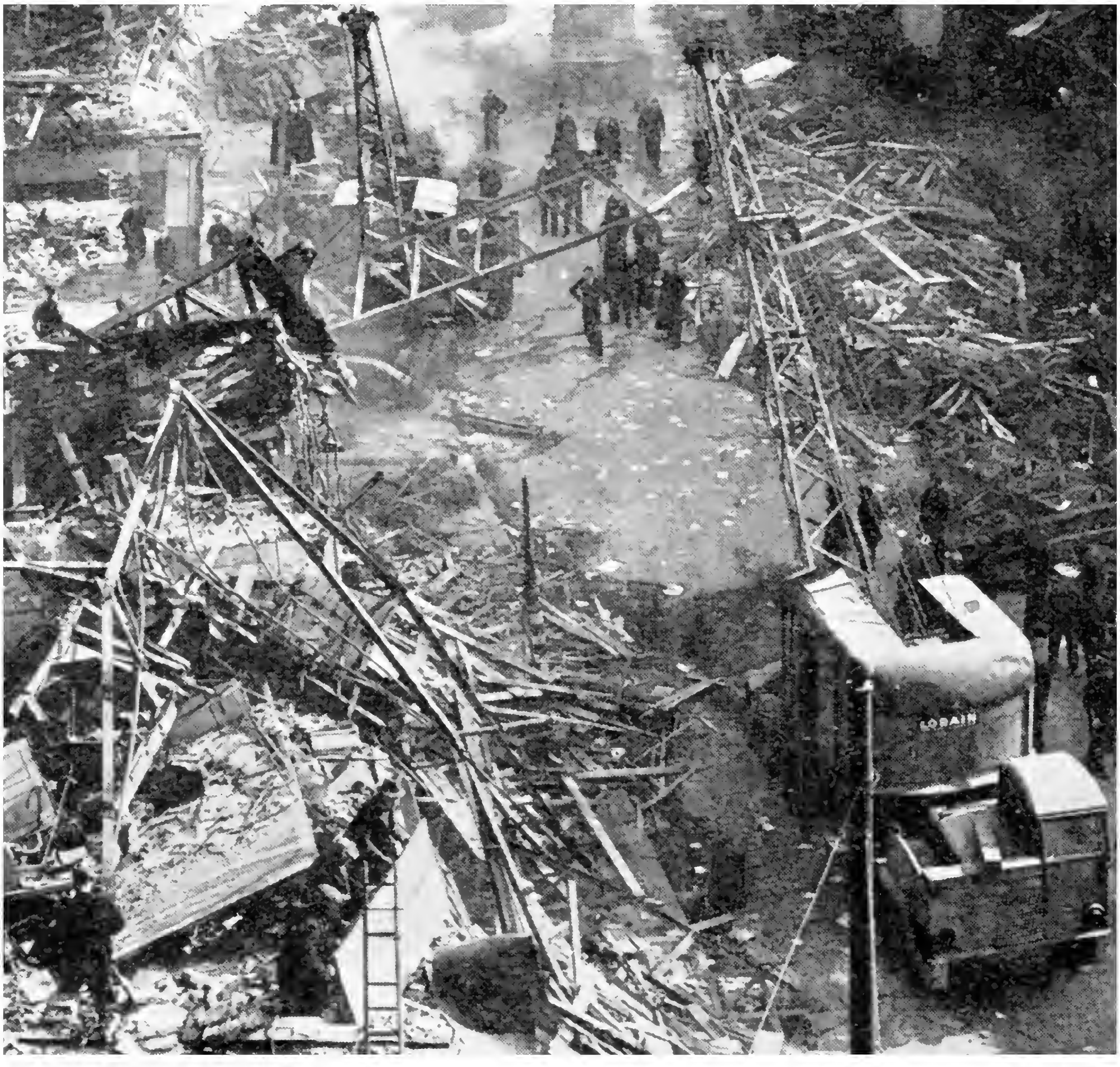
RESCUE MANUAL

LONDON
HER MAJESTY'S STATIONERY OFFICE
1952

CHAPTER XI. USE OF HEAVY MECHANICAL PLANT IN RESCUE, DEMOLITION AND CLEARANCE OPERATIONS

In the last war it was found that at major incidents the use of heavy mechanical plant was frequently necessary in support of rescue operations. Such equipment was used to help in the quick removal of debris ; to lift heavy blocks of brickwork or masonry ; to take the weight of collapsed floors and girders so that voids could be explored and casualties extricated ; to haul off twisted steelwork and other debris and to break up sections of reinforced concrete.

In future all these tasks may be required and heavy clearance may have to be effected to enable rescue and other Civil Defence vehicles



8 March 1945 Fig. 20 **1 ton of TNT equivalent**

Using heavy mechanical plant at the Smithfield Market V.2 incident.

to approach within measurable distance of their tasks. The problem of debris will in fact be a major factor in Civil Defence operations.

Heavy mechanical plant may be required for the following purposes :

(*a*) To assist in the removal of persons injured or trapped. At this stage mainly heavy plant is needed, particularly mobile cranes with sufficient length of boom or jib to reach for long distances over the wreckage of buildings.

(*b*) To force a passage for Civil Defence vehicles and fire appliances to enable them to reach areas where major rescue and other problems exist and require urgent operational action.

(*c*) To take certain safety measures—e.g., to pull down unsafe structures.

(*d*) To clear streets and pavements to help restore communications and to afford access for the repair of damaged mains and pipes beneath the streets.

(*e*) For the final clearance of debris and the tidying of sites. This is a long term and not an operational requirement.

Urgent Rescue Operations

During rescue operations in London in the last war the machines used with great success included heavy 3½-5 ton mobile cranes, mounted on road wheels, with a 30-40 ft. jib ; medium heavy 2-3½ ton mobile cranes, mounted on road wheels, with a 26 ft. jib ; heavy crawler tractor bulldozers ; medium crawler tractor bulldozers ; mechanical shovels and compressors, three stage, mounted on road wheels.

In the case of a large or multiple incident where access was obstructed by considerable quantities of scattered debris, a bulldozer or tractor was first employed in order to clear one or more approaches by which other equipment and personnel could reach the scene of operations.

Next, all debris of manhandling size was loaded into one-yard skips and discharged by the crane into lorries, giving increased manœuvring space to the Services operating on the site.

Heavy mobile cranes were then brought up to the incident where, used under the skilled direction of the rescue party Leader, they were invaluable for removing girders and large blocks of masonry which obstructed access to casualties or persons trapped. The necessary chains and wire ropes for these operations formed part of the standard equipment of the heavy and medium-heavy mobile cranes.

The work was, of course, carried out in close co-operation with the Rescue Parties who also used various forms of light mechanical equipment, such as jacks and ratchet lifting tackle for work in confined spaces.

Compressors sometimes proved valuable for breaking up large masonry such as fallen walls, into sections of a size and weight within the handling and lifting capacity of the cranes. This method was only used when it was known that there were no casualties under the masonry.

FIRE AND THE ATOMIC BOMB

Fire Research Bulletin No. 1

PUBLISHED FOR THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE BY HER MAJESTY'S STATIONERY OFFICE, LONDON: 1954

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
AND FIRE OFFICES' COMMITTEE

FIRE RESEARCH

BULLETIN NO. 1

FIRE AND THE ATOMIC BOMB

BY

D. I. LAWSON, M.Sc., M.I.E.E., F.Inst.P.

LONDON: HER MAJESTY'S STATIONERY OFFICE
1954

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Charles House,
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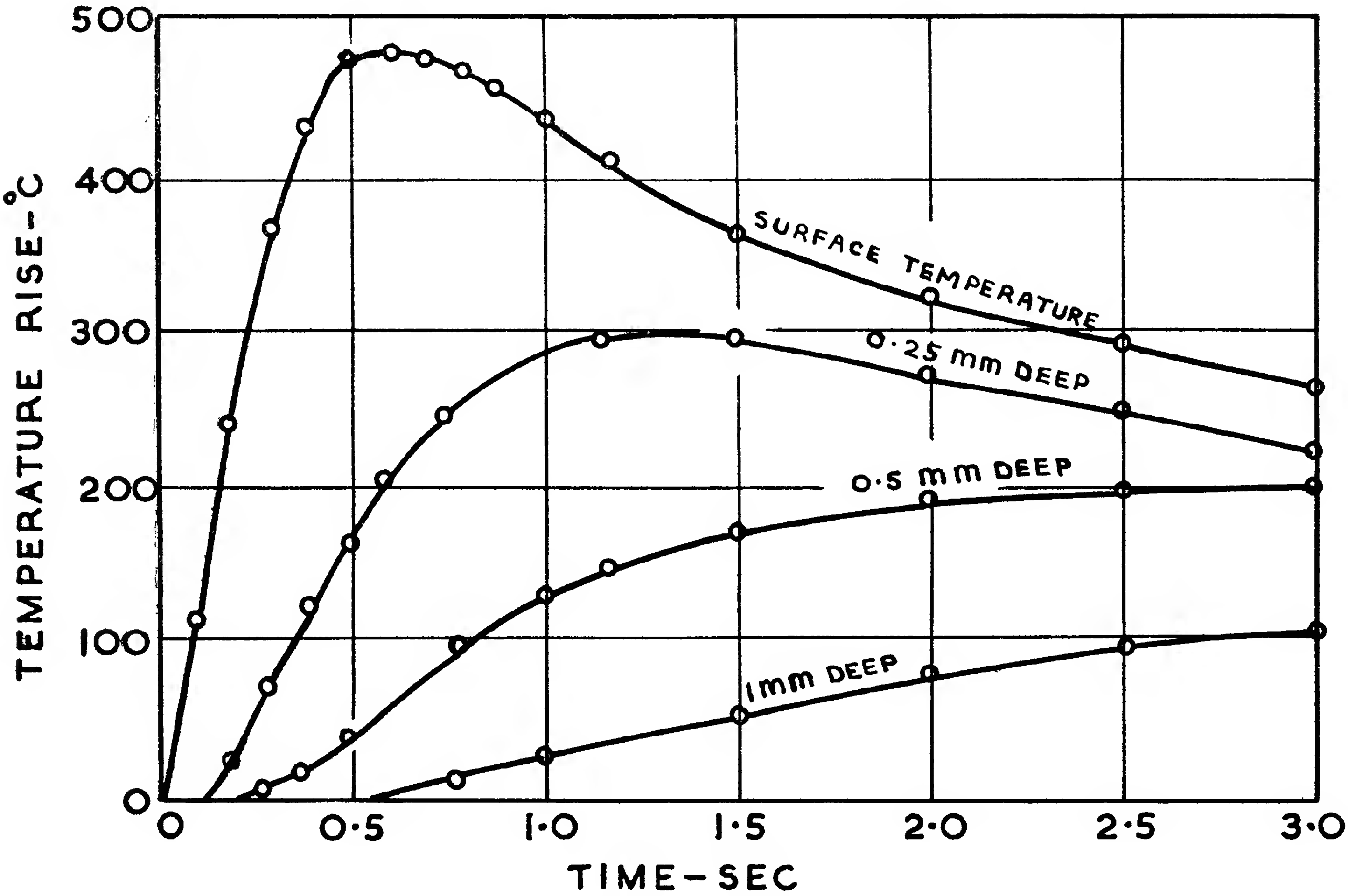
PAGE 5:

The amount of heat received by unit area of a surface in one second provides a convenient unit for measuring radiation. The scientific unit of heat is the calorie. This is the amount of heat required to raise the temperature of one gramme of water by one centigrade degree.

TABLE 1

THE EFFECT OF VARIOUS INTENSITIES OF RADIATION

Sensation or effect	Intensity cal/cm²/sec
Summer sunshine in England	0·016
Pain after 3 sec	0·25

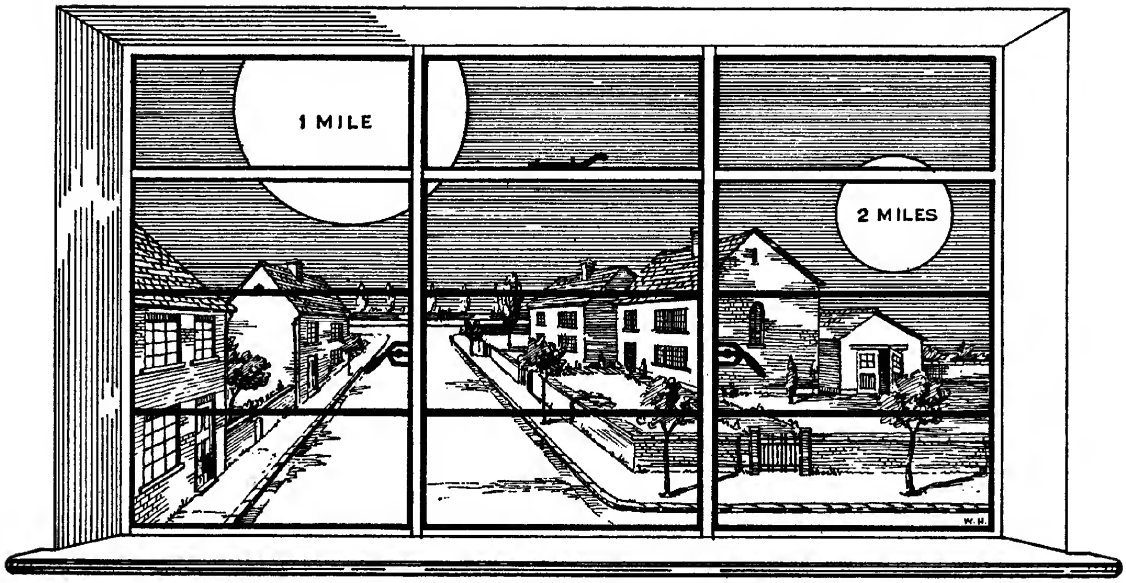


20 KT TIME-TEMPERATURE CURVES FOR MAHOGANY WHEN IRRADIATED WITH A PEAK INTENSITY OF 5·9 CAL/CM²/SEC

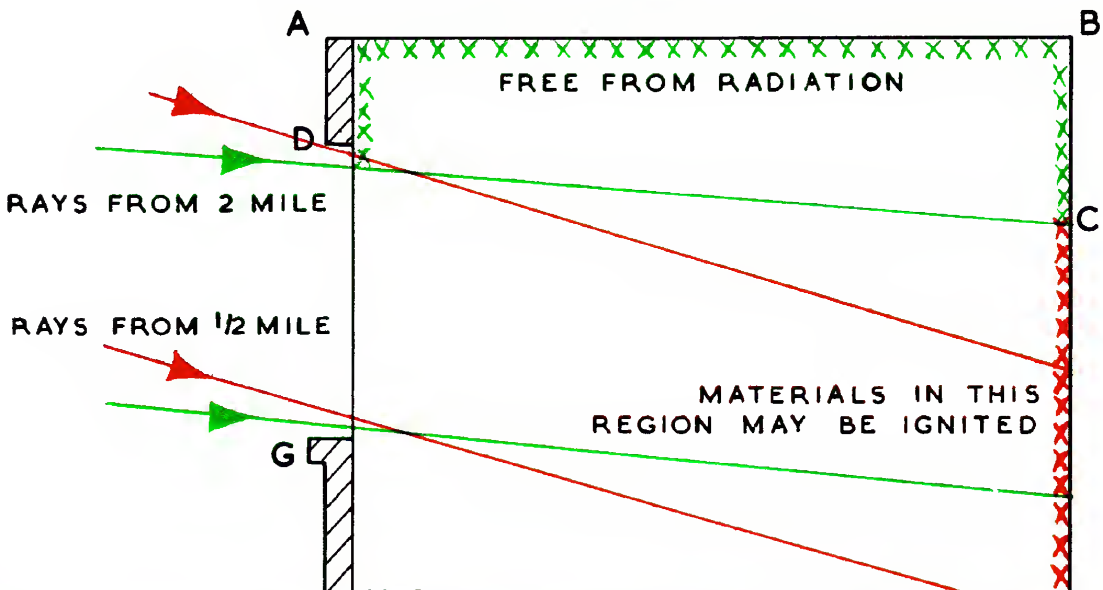
PAGE 13:

The radiation falling on any material will heat up the surface and if the radiation is sufficiently intense to bring the surface to a temperature of about 500°C, it will burst into flames. Two factors tend to prevent this : first, as soon as the surface becomes hot it proceeds to lose heat by conduction to the bulk of the material behind the surface, and secondly, heat is lost by the increased radiation from the surface.

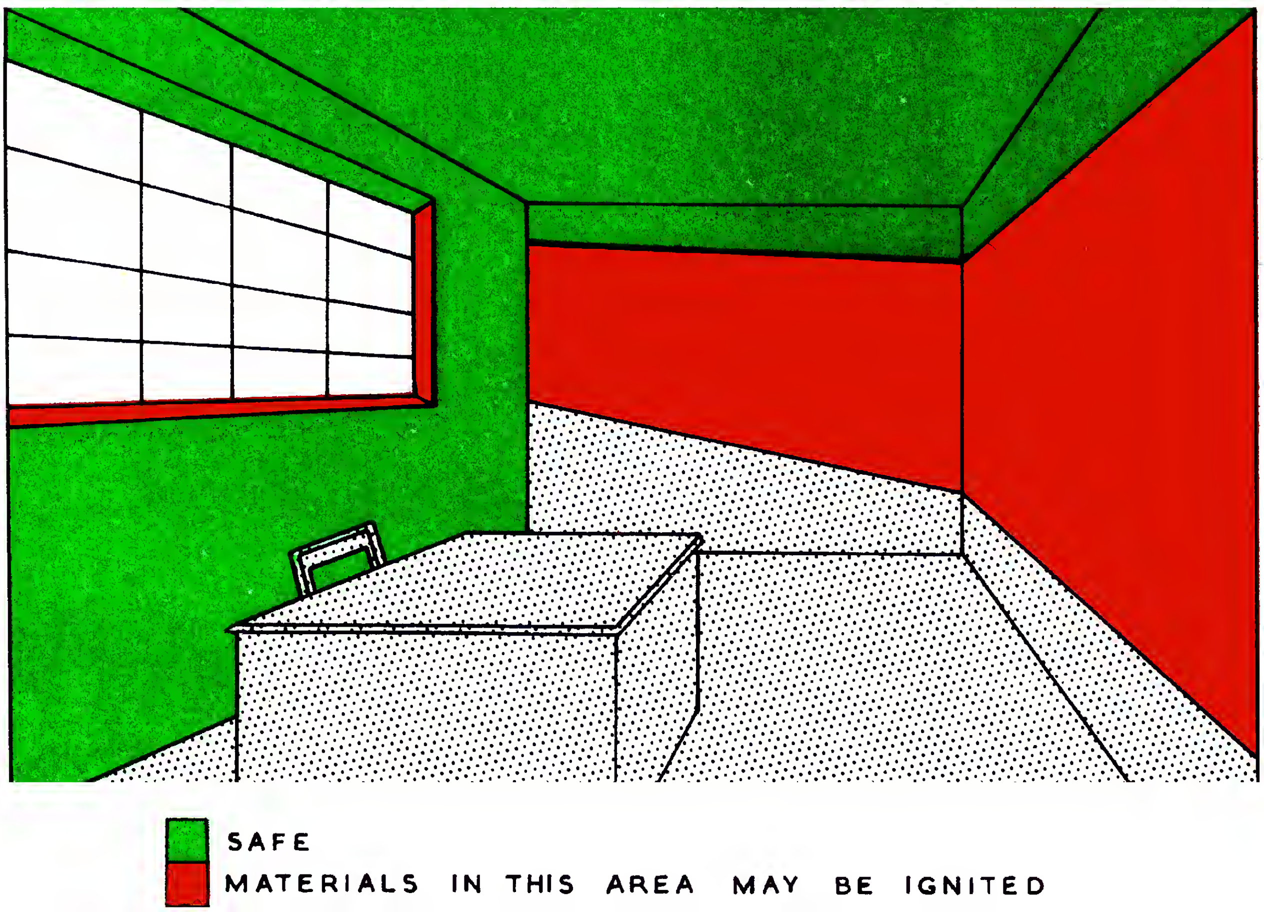
. . . the water has to be heated and finally vaporized at 100°C before the temperature of the wood can rise to the ignition point.



APPARENT POSITION OF FIRE BALL
(Height of burst 600 ft.)



HAZARDS OF IGNITION BY FLASH OF VARIOUS AREAS IN A ROOM



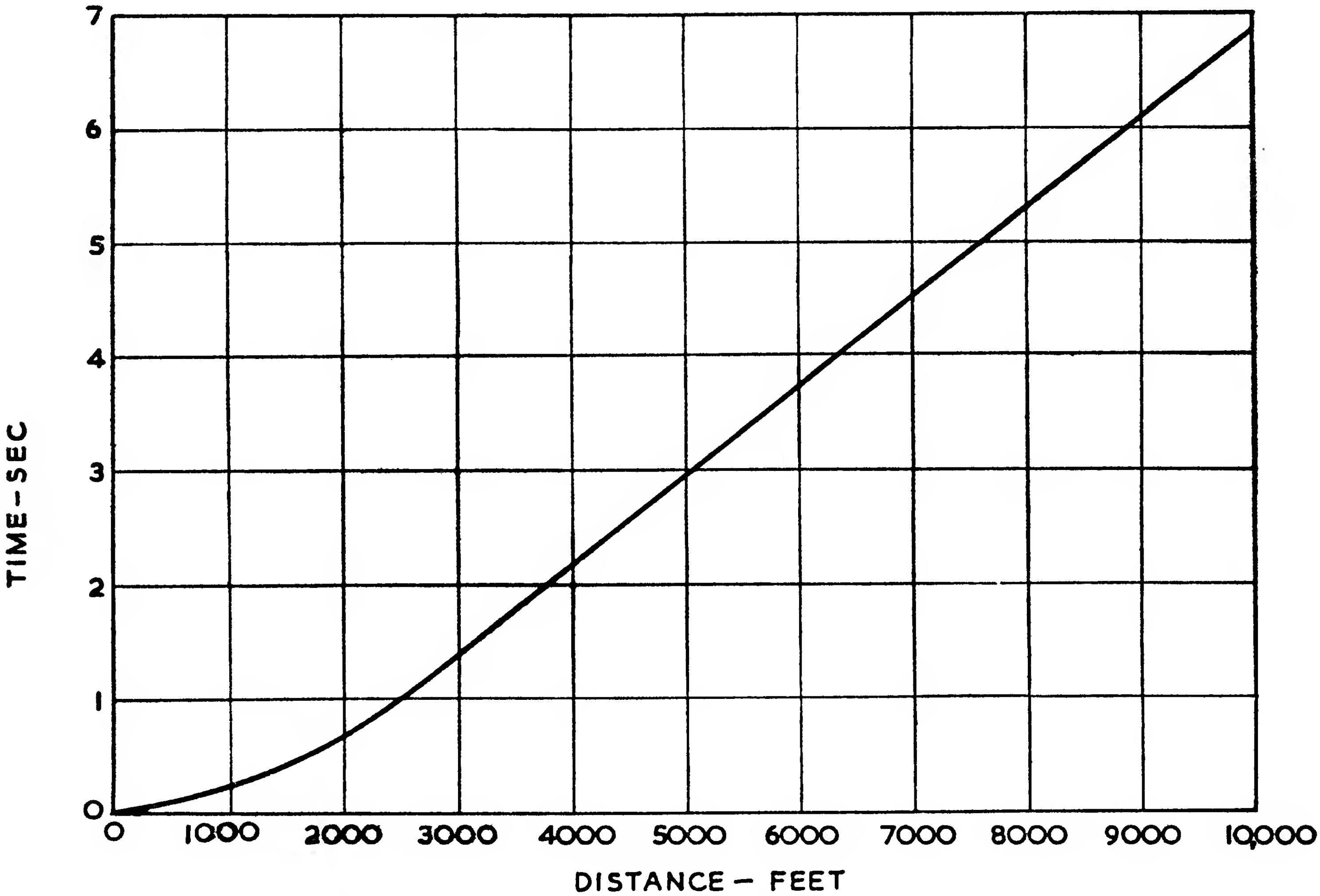
PAGES 13-14:

It seems unlikely that flat wooden surfaces exposed to radiation from the bomb will give rise to a continuing fire.

. . . The temperature below the surface falls away very rapidly. Once the surface is ignited, the material will burn to a depth at which a temperature of 250°C has been reached. It will be seen that the burning is very superficial and does not penetrate to a depth of more than 0·4 mm ; this would not, in all probability, give rise to a continuing fire.

THE PHYSIOLOGICAL EFFECT OF HEAT RADIATION

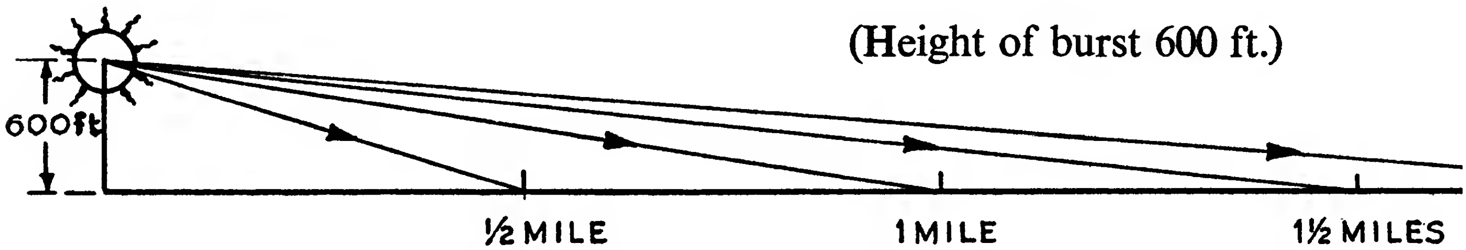
If a sufficient quantity of heat radiation falls on the human skin, burns will result which are similar to those obtained by handling hot bodies. These, of course, may be prevented by covering the exposed parts of the skin with some material which is not readily flammable, for example leather or woollen gloves would be suitable for the hands, and a woollen or treated cotton Balaclava for the face. Estimations have been made by Buettner of the intensity of radiation necessary to produce permanent tissue necrosis at various depths in the skin for exposures of 2 seconds to constant radiation intensities of 1·0, 1·5, 2·0, 2·5, and 3·0 cal/cm²/sec ; the results indicate that necrosis will occur up to 0·05, 0·24, 0·42, 0·56, and 0·66 mm.



20 KT TIME OF ARRIVAL OF BLAST

PAGE 19:

It is not likely that fires will be started on the exterior surfaces of buildings. Doors and window frames may inflame momentarily, but as we have seen, it is unlikely that they will cause continuing fires. The main danger will come from the materials usually found indoors. The walls of the buildings are, of course, opaque to heat and light radiation, so that this could only enter by means of windows or doors that open directly to the outside.



DIRECTION OF HEAT FLASH RAYS AT VARIOUS DISTANCES

The first fire precaution is to keep as far as possible all readily flammable materials outside the danger zone. These include papers, textiles, upholstery, etc. Plane wooden surfaces will not cause a continuing fire and it would only be necessary to move furniture if it were upholstered. The second precaution is to try to stop the heat radiation entering the room, and this can be done, for example, by fixing some incombustible board across the window space. Any board which is opaque to light radiation will also form a barrier to the heat.

PAGE 21:

Glass will pass nearly all visible radiation, that is why it can be seen through ; but it is quite efficient at stopping heat radiation, and will in fact absorb about two-thirds of that falling on it. The absorption of glass for both heat and light radiation can be improved by coating it with white paint or whitewash and when the coverage is 14 sq. ft./lb., the glass will pass only one-fifth of the radiation falling on it.

PAGE 25:

Curtains and blackout may be treated with a solution of boric acid and borax. This will prevent the ignition of these cotton fabrics during the flash period until the intensity has been raised by about 40 per cent over that normally required for ignition, but more important still, it will remove the chance of a continuing fire. This solution would not, of course, be suitable for the treatment of upholstery or papers which it is necessary to leave lying about. These should be covered by sheets treated with borax-boric acid solution, woollen blankets, or polyvinyl chloride sheeting, or in fact any material which is not readily ignited. If the suggested treatments are carried out white cotton will require an intensity of about 4·9 cal/cm²/sec before ignition takes place. Five times as much radiation as this could be allowed to fall on the glass window before ignition takes place, as four-fifths would be stopped by the treated glass.

City skyline shielding in an air burst at 600 ft over Birmingham, 1952. Over 50% of the buildings were shielded, preventing a firestorm (144:1 scale model).

SOURCE: George R. Stanbury, The Fire Situation After an Attack on a British City, Technical and Tactical Study Courses, May, June and July 1952, Fire Service College, London: The Home Office (Fire Service Department).

HOME OFFICE

CD/SA 121

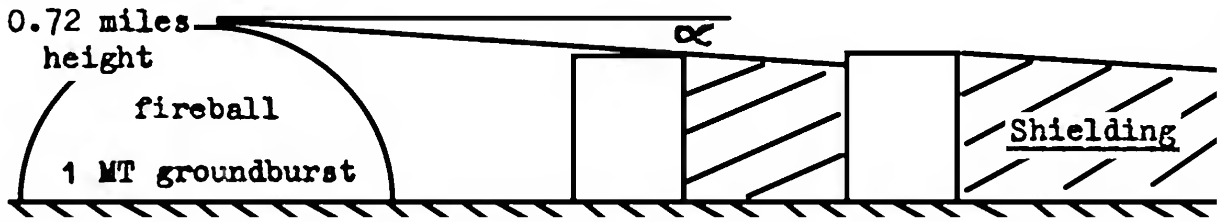
SCIENTIFIC ADVISER'S BRANCH

(Paper at Tripartite Thermal Effects Symposium, Dorking, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE



Thermal pulse precedes the blast wave

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height we take the average depth of a floor to be 10 ft.

Effect of Shielding: Estimation of the number of exposed floors

Distance from explosion miles	Angle of arrival α^o	Width of street (units of 10 ft.) 2	3	4	5	6	7	8
3	$13\frac{1}{2}$	.5	.5	1	1	1.5	1.5	2
4	10	.5	.5	.5	1	1	1.5	1.5
5	8	.5	.5	.5	.5	1	1	1

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the fire-storm raid on Hamburg, 27th/28th July, 1943

102 tons H.E.	48 tons, 4 lb. magnesium	40 tons, 30 lb. gel.
100 fires	27,000 bombs	3,000 bombs
	8,000 on buildings	900 on buildings
	1,600 fires	800 fires

2,500 fires in 6,000 buildings

However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire

When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of $\sim$ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

SECONDARY FIRES FROM BLAST DAMAGE IN LONDON

Fire situation from 1,499 fly bombs in the built-up part of the London Region

(Fires from 1 ton TNT V1 cruise missiles, 1944)

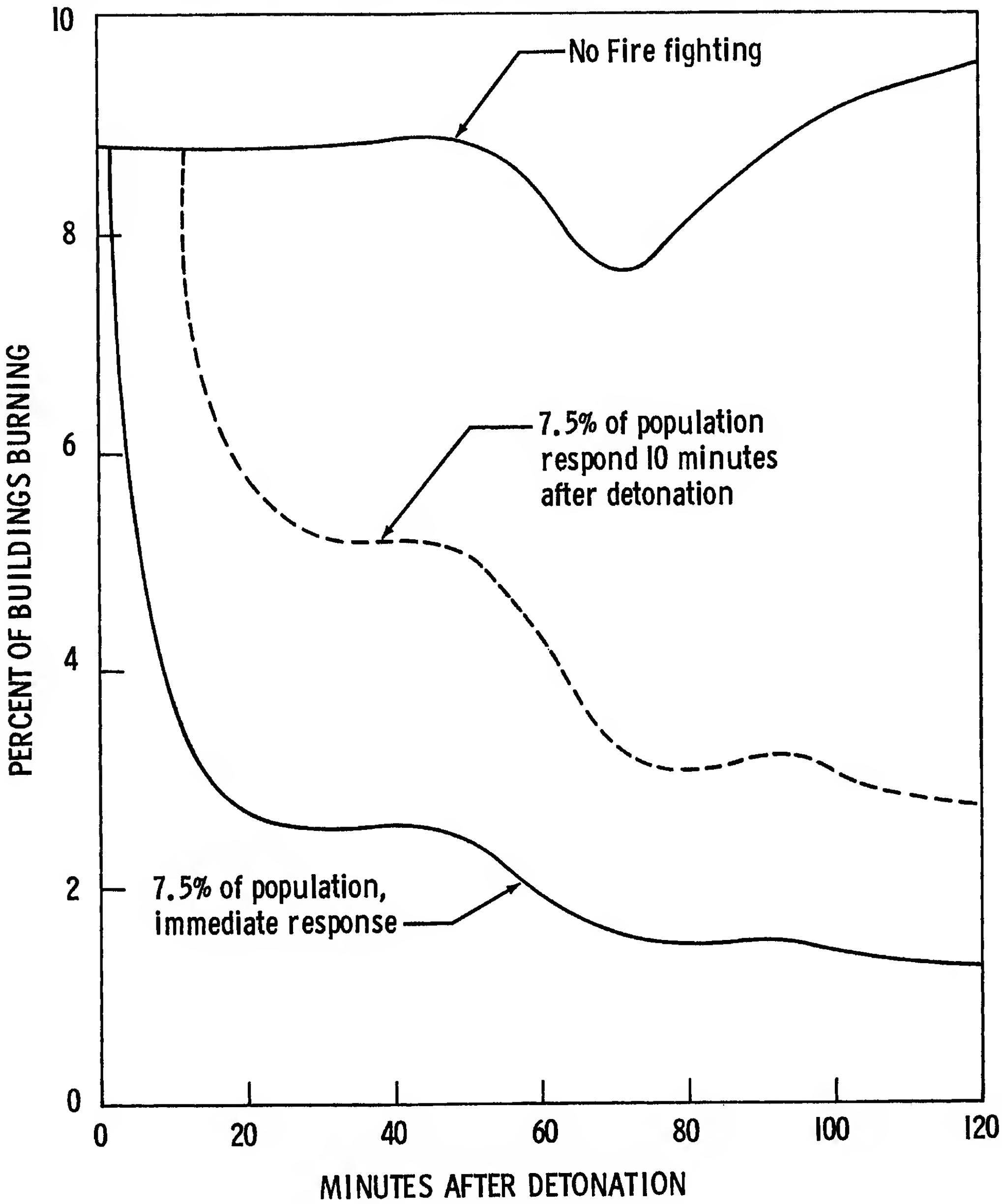
	Number of fly bombs	Fly Bombs Caused				
		No fire	Small fire	Medium fire	Serious fire	Major fire
Grand Totals	1,499	804	609	75	7	4

The large proportion started no fires at all even in the most heavily built-up areas.

All these fly bombs fell in the summer months of 1944 which were unusually dry. In winter in this country in residential areas there are many open fires which may provide extra sources of ignition. The domestic occupancy is a low fire risk however, and as the proportion of such property in the important City and West End areas is small this should not introduce any serious error. Moreover, in winter, the high atmospheric humidity and the correspondingly high moisture content of timber would tend to retard or even prevent the growth of fire.

Takata, A.N., **Mathematical Modeling of Fire Defenses,**

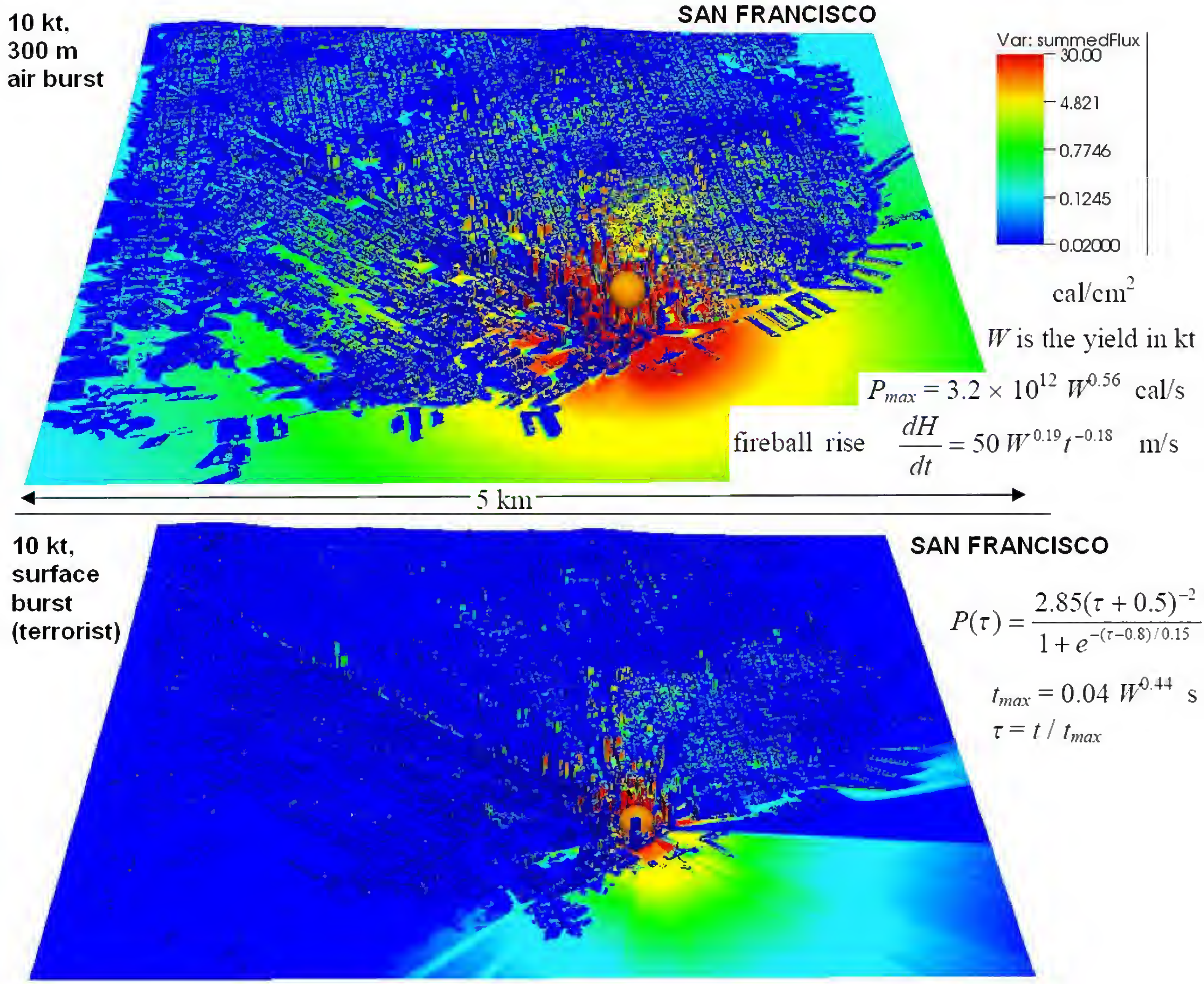
IITRI, March 1970, AD 705 388.



Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, and B. Whitlock
Lawrence Livermore National Laboratory

UCRL-TR-231593
June 7, 2007



Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

A. M. Western "Some simplified theories about mass fires". Proceedings of Mass Fire Research Symposium held DASA, Washington D.C. February 1967. DASIAC special report 59 published October 1967.

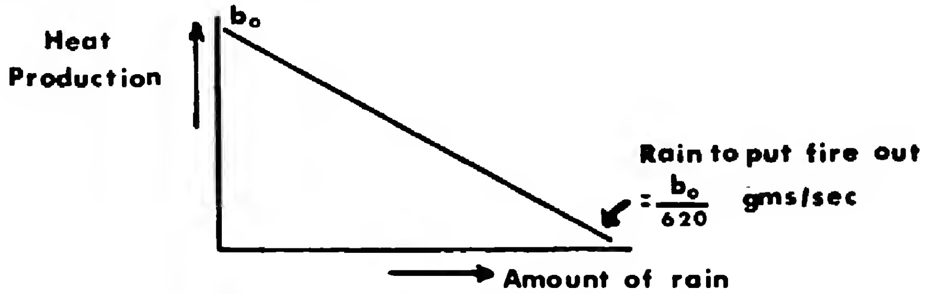
December 1966 SA/PR 102 (Revised)

HOME OFFICE

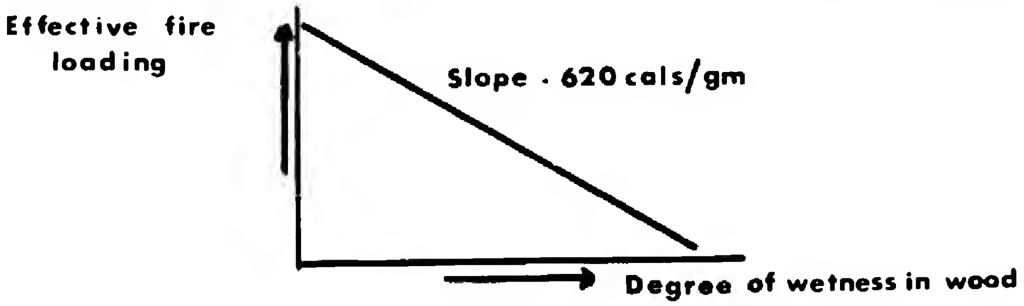
SCIENTIFIC ADVISER'S BRANCH

Some simplified theories about mass fires
by A.M. Western

11 If rain falls during a burn, heat production is reduced by 620 cals per gram of water falling on a pile.



12 If wood is wet, fire loading is reduced by 620 cals/gram of water.



March 1968 SA/PR 130

HOME OFFICE

SCIENTIFIC ADVISER'S BRANCH

Water Calorimeters and Burning Rates in Flambeau 1967

by A. M. Western

Application to Firestorms

14. Historical firestorms were marked by an unusually high casualty rate - about 20% at Hamburg. Why was this so?

Trapping by heat & fumes

As the fire density is increased, the casualty rate starts to climb steeply when the lethal radius about each fire starts to overlap with its neighbour's. Applying this to terraced housing, assume a man is a casualty if his house, the house opposite the front door, and the house opposite the back door, are all alight.

Hence Casualty rate = C = p^3 ....(i)
where p = fraction of houses alight.

For example, if p = 10%, which is reasonable for many group fires, then C = 0.1%, while for p = 60%, which is the order of magnitude of ignitions in Hamburg, C = 22%. Hence this theory could explain the high casualty rate on its own.

CRASH CIVIL DEFENSE PROGRAM STUDY

by
K. E. Willis
E. R. Brooks
L. J. Dow

AD0403071

April 30, 1963

Prepared for
OFFICE OF CIVIL DEFENSE
UNITED STATES DEPARTMENT OF DEFENSE

Feasibility

In the typical household, some materials will generally be available for covering windows against thermal radiation. One half roll of aluminum foil would cover about 25 ft^2 and would provide very effective covering for 1 to 2 windows (those most likely to face the blast). Sufficient quantities of either light colored paint, Bon Ami, or whiting would be available in most households to cover windows. Aluminum screens attenuate from 30 - 50% of the thermal radiation and hence screens should be closed or installed.

The amount of water per square foot required to dissipate 25 cal/cm^2 of thermal radiation can quickly be calculated from the heat of vaporization of water (580 cal/gm). Allowing 90% losses due to absorption or spillage, one gallon of water is sufficient to wet 10 ft^2 of material so that it can withstand 25 cal/cm^2 of direct thermal radiation (i.e., the radiation is normal to the material surface at all points). Since the average daily water consumption per service (Reference 3) is about 700 gallons, it is apparent that the wetting of interior flammables (piled up curtains, furniture, etc.) is feasible in most cases when used in conjunction with the other measures.

3. Statistical Abstracts of the United States. Washington: U. S. Government Printing Office, 1962.

FIRE FIGHTING FOR HOUSEHOLDERS

Folded newspapers may not take fire, but loosely crumpled ones will. The answer? Get rid of trash.

A wet mop or broom will snuff out small fires. So will a burlap bag or a small rug soaked in water.

Buckets of water and sand are essential.

Water is an effective fire fighting agent because it smothers and cools at the same time.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

The probable fire situation in a British city

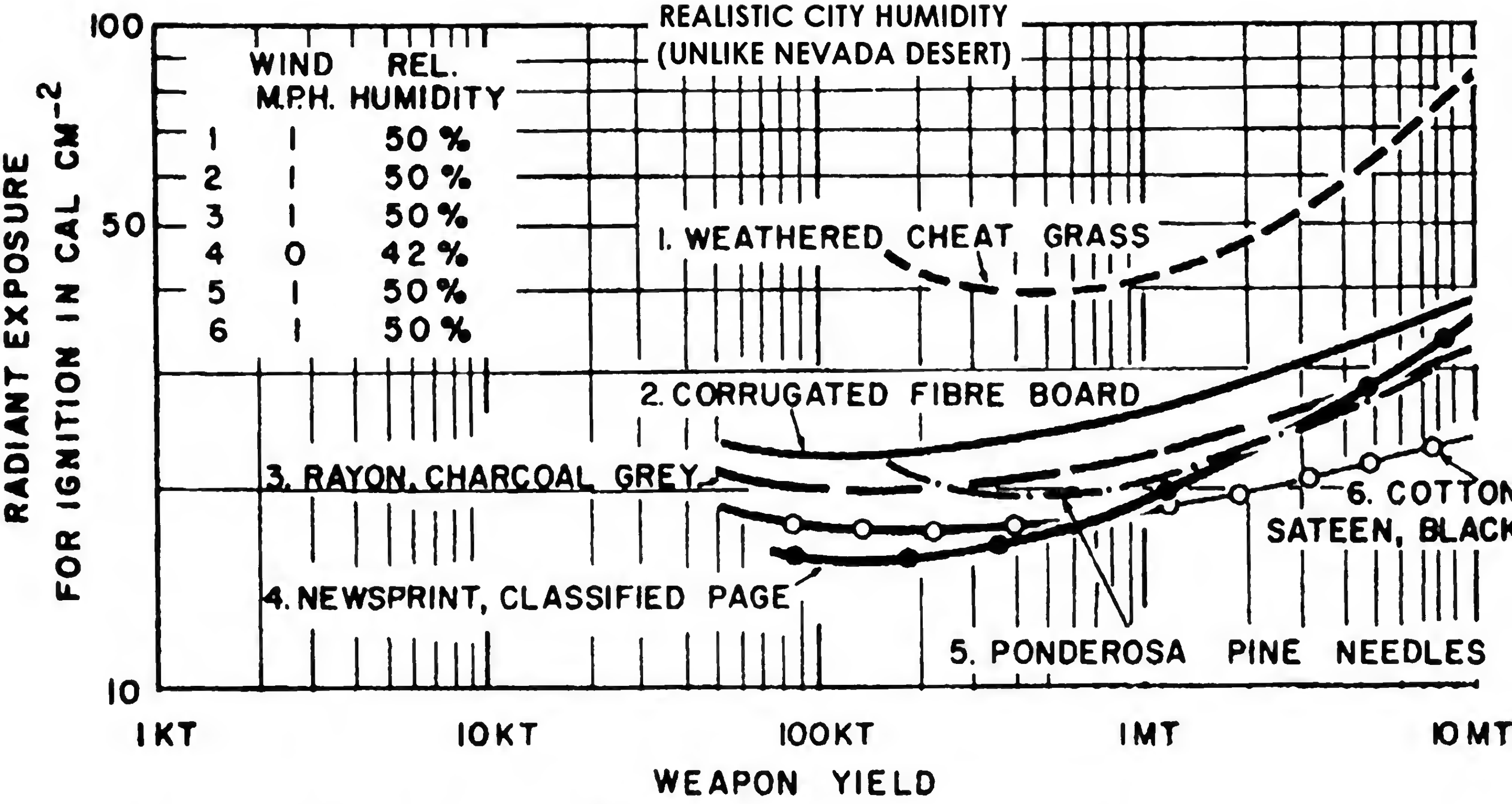
35 Japanese houses are constructed of wood and once they were set on fire they continued to burn even when knocked over. In this country only about 10 per cent. of all the material in the average house is combustible, and under conditions of complete collapse, where air would be almost entirely excluded, it is doubtful whether a fire could continue on any vigorous scale.

40 It seems unlikely from the evidence available that an initial density of fires equivalent to one in every other building would be started by a nuclear explosion over a British city. Studies have shown that a much smaller proportion of buildings than this would be exposed to thermal radiation and even then it is not certain that continuing fires would develop. Curtains may catch fire, but it does not necessarily follow that they will set light to the room; in the last war it was found that only one incendiary bomb out of every six that hit buildings started a continuing fire.

From a 10 megaton bomb, with its longer lasting thermal radiation (see paragraph 21), it takes about 20 calories per square centimetre to start fires because so much of the heat (spread out over the longer emission) is wasted by conduction into the interior of the combustible material and by convection and re-radiation whilst the temperature of the surface is being raised to the ignition point. But the distance at which 20 calories per square centimetre can be produced is only 11 miles, so that the scaling factor for a 10 megaton airburst bomb is therefore 11 and not 22.

43 For a ground burst bomb, however, several other factors contribute to a further reduction in the fire range. Apart from an actual loss of heat by absorption into the ground and from the pronounced shielding effect of buildings, the debris from the crater tends to reduce the radiating temperature of the fireball and a greater proportion of the energy is consequently radiated in the infra red region of the spectrum—this proportion being more easily absorbed by the atmosphere.

44 An important point in relation to personal protection against the effects of hydrogen bomb explosions is that because the thermal radiation lasts so long there is more time for people who may be caught in the open, and who may be well beyond the range of serious danger from blast, to rush to cover and so escape some part of the exposure. For example, people in the open might receive second degree burns (blistering) on exposed skin at a range of 16 miles from a 10 megaton ground burst bomb (8×2—see paragraph 24). If, however, they could take cover in a few seconds they would escape this damage. Moreover, at this range the blast wave would not arrive for another minute and a half so that any effects due to the blast in the open (e.g. flying glass, etc.) could be completely avoided.



"TECHNICAL OBJECTIVE AW-7, CRITICAL RADIANT EXPOSURES FOR PERSISTENT IGNITION", JULY 1960, J. BRACCIAVENTI & F. DEBOLD AD-249476; DASA-1194

UCRL-TR-231593

Thermal radiation from nuclear detonations in urban environments

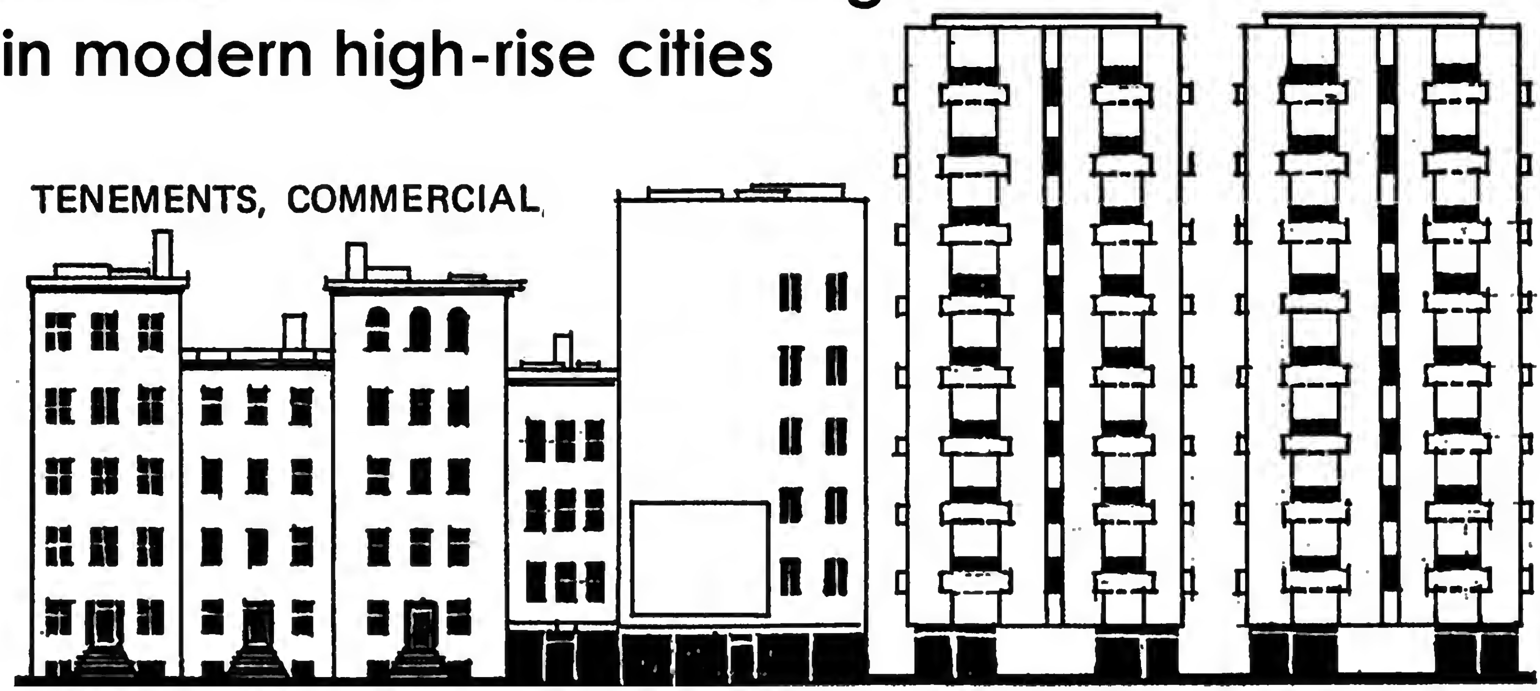
LAWRENCE LIVERMORE NATIONAL LABORATORY

June 7, 2007

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

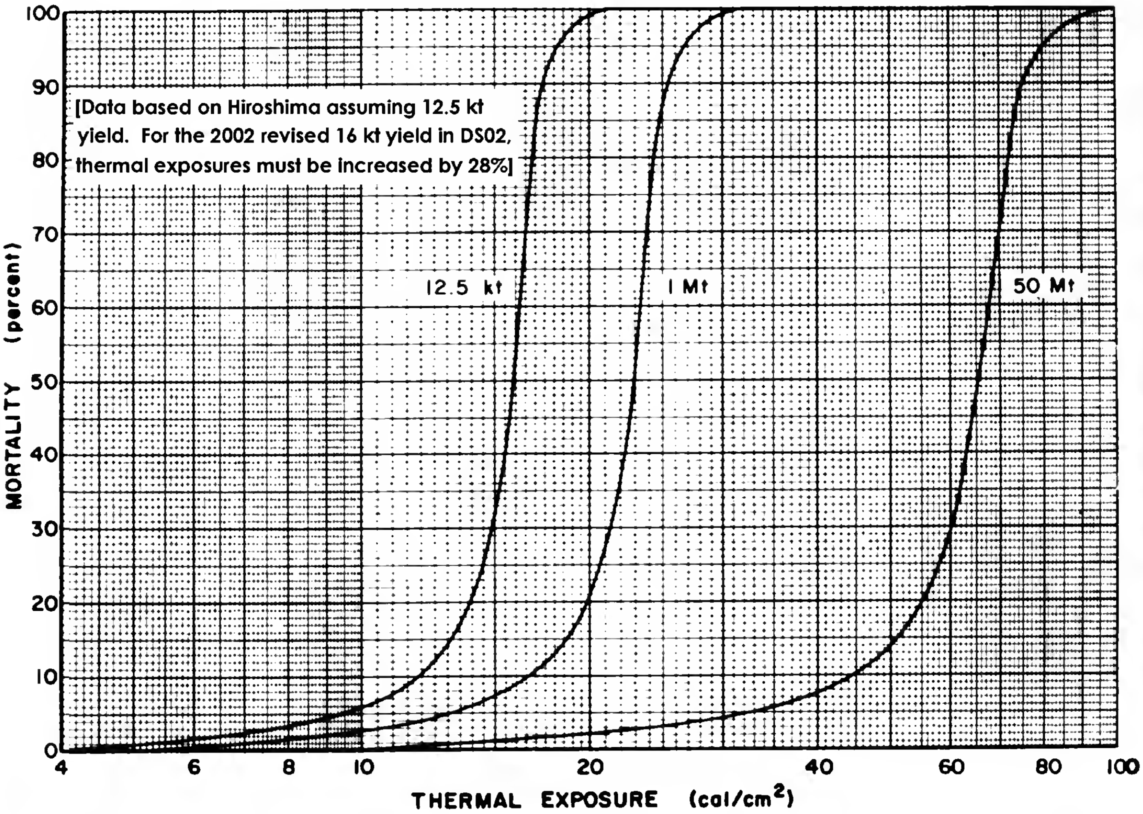
We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

Thermal radiation shadowing in modern high-rise cities



L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS FOR OUTSIDE-UNSHIELDED PERSONS



Unless you are nude outdoors, 6.7 cal/cm^2 is not lethal, contrary to the OTA report!

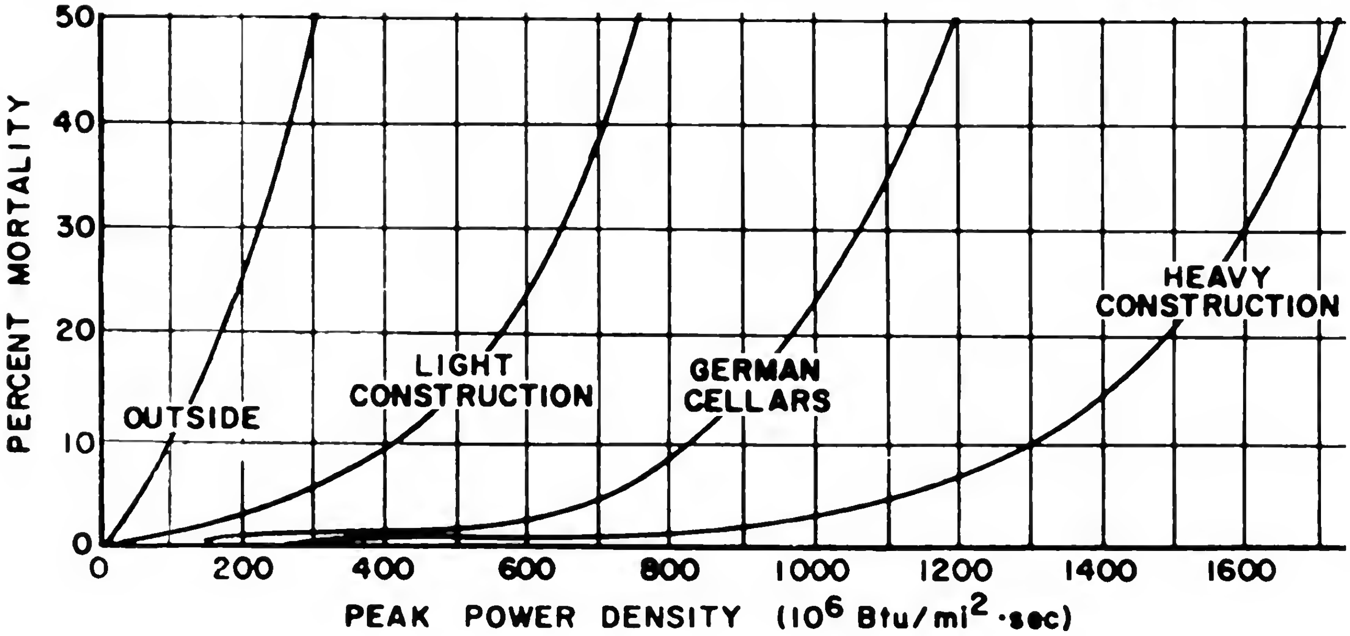
Shirt protection: Nagasaki

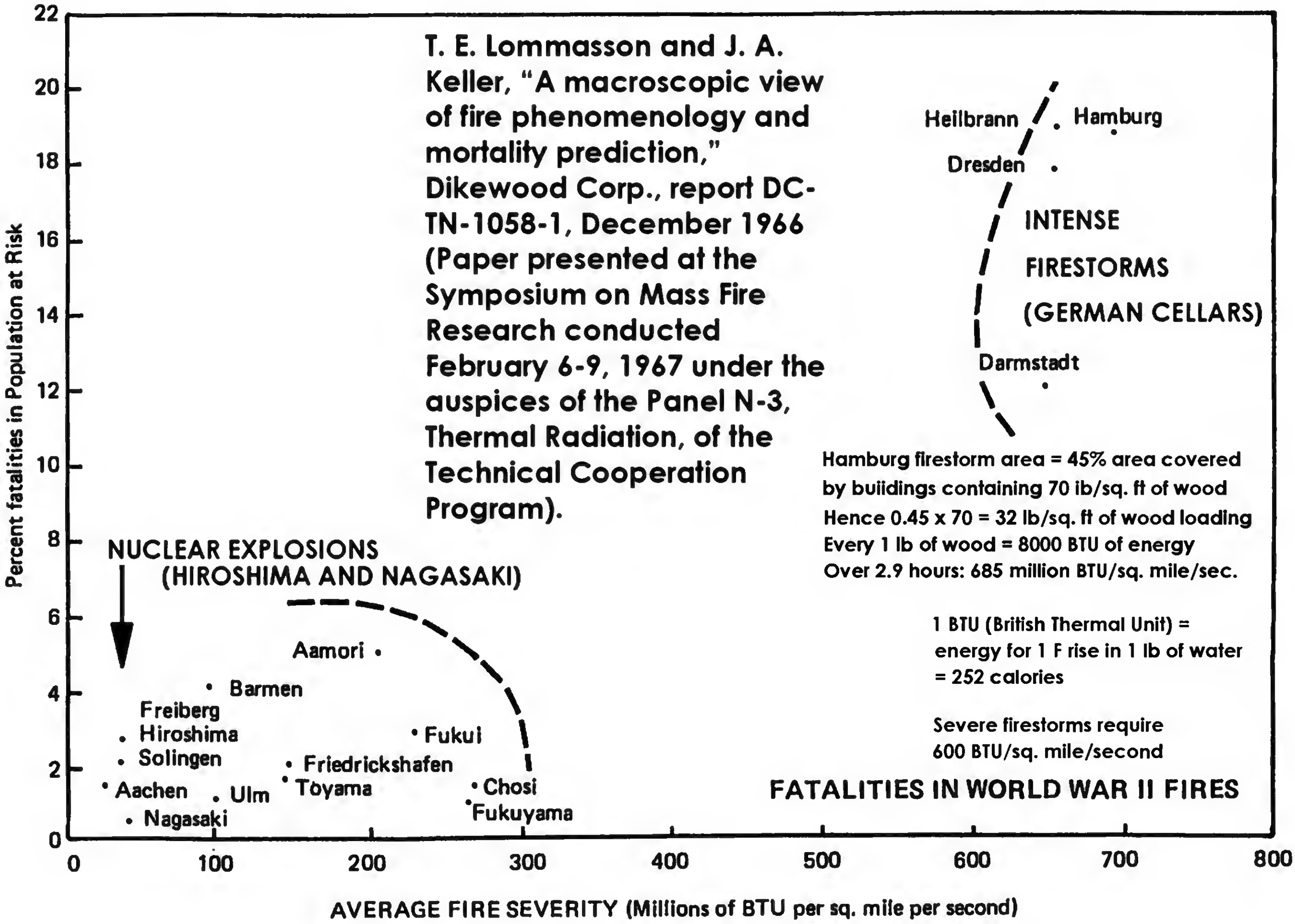
Uniform protection: Hiroshima, "lethal" 6.7 cal/cm^2 !!!

PROTECTION AGAINST RADIANT HEAT. This patient (photographed by Japanese 2 October 1945) was about 6,500 feet from ground zero when the rays struck him from the left. His cap was sufficient to protect the top of his head against flash burns.

Above: Hiroshima soldier only burned on unclothed skin (1946 USSBS report on Hiroshima and Nagasaki, page 16)

FIRE MORTALITY CURVES **DC-P-1060**





Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions**, Dikewood Corporation, DC-TN-1058-1, December 1966.

J. A. Keller, A Study of World War II German Fire Fatalities, DC-TN-1050-3, The Dikewood Corporation; April, 1966.

R. Schubert, Examination of Building Density and Fire Loading in the Districts Eimsbuettel and Hammerbrook of the City of Hamburg in the Year 1943 (20 volumes, in German), Stanford Research Institute; January, 1966.

DNA EM-1
PART I
1 JULY 1972

DEFENSE NUCLEAR AGENCY EFFECTS MANUAL NUMBER 1

CAPABILITIES OF NUCLEAR WEAPONS

PART I
PHENOMENOLOGY

HEADQUARTERS
Defense Nuclear Agency
Washington, D.C. 20305

EDITOR
PHILIP J. DOLAN
STANFORD RESEARCH INSTITUTE

A parameter that is useful for calculating thermal response of materials is the characteristic thermal response time τ_0, given by the equation

$$\tau_0 = \rho C_p L^2/k \text{ sec},$$

where k is thermal conductivity (cal-sec^{-1} cm^{-1}°C^{-1}), ρC_p is heat capacity per unit volume (ρ = density in g-cm^{-3} and C_p = specific heat at constant pressure in cal-g^{-1}°C^{-1}), and L is the thickness, in centimeters, of the layer of material.

The quantity

$$\alpha = \frac{k}{\rho C_p}$$

is called thermal diffusivity (cm^2/sec). Use of this quantity simplies the previous equation to

$$\tau_0 = \frac{L^2}{\alpha} \text{ sec.*}$$

For any particular material exposed to a rectangular pulse of length τ, the previous equation can be transformed to give a characteristic thickness

$$\delta = \sqrt{\alpha\tau} \text{ cm},$$

for which the characteristic time is equal to the pulse duration. If a thick slab of this material is exposed to a pulse of length τ, the temperature rise at the surface is the same as would be produced by uniformly distributing the absorbed thermal energy in a slab of thickness δ, and the peak temperature rise at depth δ in the thick slab is about half as great as the peak temperature rise at the surface.

For example, consider a block of red pine that is exposed to 15 cal/cm^2 from a rectangular pulse of 3 seconds duration. From Table 9-1,

$$\delta = \sqrt{\alpha\tau} = \sqrt{(24 \times 10^{-3})(3)} = 0.085 \text{ cm}.$$

*This equation is useful, but it is by no means exact. The simplified heat-flow analysis from which this equation is derived neglects the effects of radiation and convection heat losses from the surfaces of the exposed sample. It also assumes an isotropic medium, i.e., a medium whose structure and properties in the neighborhood of any point are the same relative to all directions through the point. It also neglects the changes in thermal properties that occur as the exposed material heats, volatilizes, chars, and bursts into flame.

The heat absorbed by the wood before it begins to scorch is equal to the product of the incident radiant energy, Q, and the absorption coefficient, A.

$$\Delta T_s = \frac{QA}{\rho\delta C_p} = \frac{QA}{\rho C_p \sqrt{\alpha\tau}} = \frac{QA}{\rho C_p \sqrt{\tau k/\rho C_p}},$$

where ΔT_s is the peak temperature rise at the surface. The parameters that define the thermal pulse may be separated from those that define the material properties, and

$$\Delta T_s = \left(\frac{Q}{\sqrt{\tau}}\right)\left(\frac{A}{\sqrt{k\rho C_p}}\right).$$

For a fixed rectangular pulse, $Q/\sqrt{\tau}$ is a constant, and the equation may be written

$$\Delta T_s = (K)\left(\frac{A}{\sqrt{k\rho C_p}}\right).$$

Sustained ignition only occurs when higher radiant exposures raise the temperature throughout the thickness of the cellulose to a level that is sufficiently high to sustain the flow of combustible gases from breakdown of the fuel. It is difficult to supply sufficient energy with short pulses, since a large amount of the energy that is deposited is carried away by the rapid ablation of the thin surface layer. This transient flaming phenomenon is typical of the response of sound wooden boards to a thermal pulse.

Table 9-1. [redacted] Thermal Properties of Materials [redacted]

Materials	Density, ρ (gm/cm^3)	Specific Heat, C_p ($cal/gm \cdot {}^\circ C$)	Conductivity, k ($cal/sec \cdot cm \cdot {}^\circ C$)	Diffusivity, α (cm^2/sec)
Insulating Materials				
Air	9.46×10^{-4}	0.24	0.55×10^{-4}	0.22
Asbestos	0.58	0.20	4.6×10^{-4}	$40. \times 10^{-4}$
Balsa	0.12	0.4	1.2×10^{-4}	$25. \times 10^{-4}$
Brick (common red)	1.8	0.2	$16. \times 10^{-4}$	$18. \times 10^{-4}$
Celluloid	1.4	0.35	5.0×10^{-4}	$10. \times 10^{-4}$
Cotton, sateen, green	0.70	0.35	1.5×10^{-4}	2.5×10^{-4}
Fir, Douglas-				
spring growth	0.29	0.4	$2. \times 10^{-4}$	$17. \times 10^{-4}$
summer growth	1.00	0.4	$5. \times 10^{-4}$	$12. \times 10^{-4}$
Fir, white	0.45	0.4	2.6×10^{-4}	$14. \times 10^{-4}$
Glass, window	2.2	0.2	$19. \times 10^{-4}$	$43. \times 10^{-4}$
Granite	2.5	0.19	$66. \times 10^{-4}$	$140. \times 10^{-4}$
Leather sole	1.0	0.36	3.8×10^{-4}	$11. \times 10^{-4}$
Mahogany	0.53	0.36	3.1×10^{-4}	$16. \times 10^{-4}$
Maple	0.72	0.4	4.5×10^{-4}	$16. \times 10^{-4}$
Oak	0.82	0.4	5.0×10^{-4}	$15. \times 10^{-4}$
Pine, white	0.54	0.33	3.6×10^{-4}	$18. \times 10^{-4}$
Pine, red	0.51	0.4	$5. \times 10^{-4}$	$24. \times 10^{-4}$
Rubber, hard	1.2	0.5	3.6×10^{-4}	$60. \times 10^{-4}$
Teak	0.64	0.4	4.1×10^{-4}	$16. \times 10^{-4}$
Metals (100°C)				
Aluminum	2.7	0.22	0.49	1.0
Cadmium	8.65	0.057	0.20	0.45
Copper	8.92	0.094	0.92	1.1
Gold	19.3	0.031	0.75	1.2
Lead	11.34	0.031	0.081	0.23
Magnesium	1.74	0.25	0.38	0.87
Platinum	21.45	0.027	0.17	0.29
Silver	10.5	0.056	0.96	1.6
Steel, mild	7.8	0.11	0.107	1.2
Tin	6.55	0.056	0.14	0.38
Miscellaneous Materials				
Ice (0°C)	0.92	0.492	$54. \times 10^{-4}$	$120. \times 10^{-4}$
Water	1.00	1.00	$14. \times 10^{-4}$	$14. \times 10^{-4}$
Skin (porcine, dermis, dead)	1.06	0.77	$9. \times 10^{-4}$	$11. \times 10^{-4}$
Skin (human, living, averaged for upper 0.1 cm)	1.06	0.75	$8. \times 10^{-4}$	$30. \times 10^{-4}$
Polyethylene (black)	0.92	0.55	$8. \times 10^{-4}$	$17. \times 10^{-4}$

Thermal flash on forest leaf canopy produces smoke-screen (in Nevada and Pacific nuclear tests), shadowing dry leaf litter

The high degree of shading by tree crowns and stems for detonations at or below the canopy level often may be offset by scattering of burning debris ignited within the fireball. 15-59

Fuels seldom burn vigorously, regardless of wind conditions, when fuel moisture content exceeds about 16 percent. This corresponds to an equilibrium moisture content for a condition of 80 percent relative humidity. 15-60

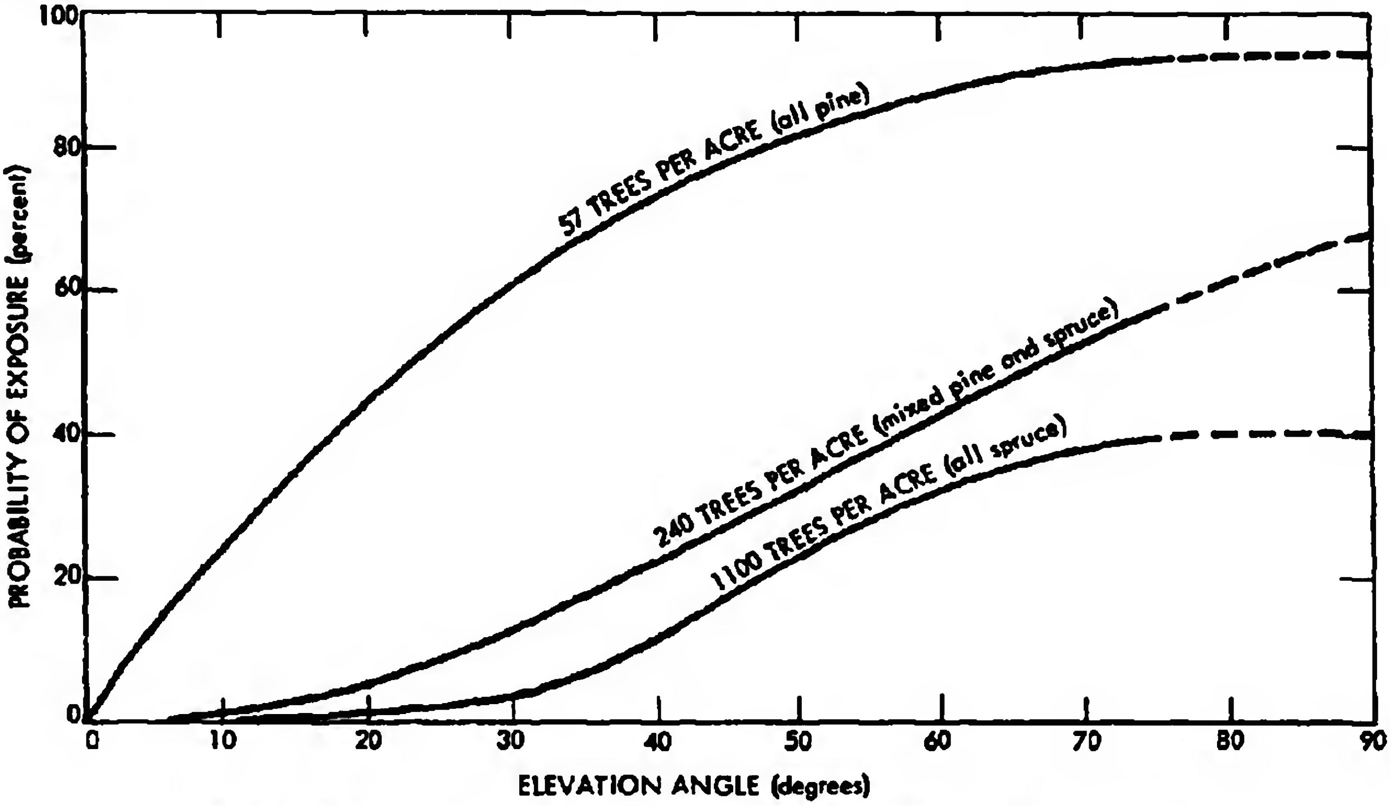


Figure 15-41. Probability of Exposure of Forest Floor for Different Levels of Tree Density

Table 15-13 Burning Durations by Fuel Type

Fuel Type	Violent Burning Time (min)	Violent Burning Energy Release (percent)	Residual Burning Time (min)	Residual Burning Energy Release (percent)	Total Burning Time
Grass	1.5	90	0.5	10	30 min
Light Brush (12 tons/acre)	2.	60	6.	40	16 hr
Medium Brush (25 tons/acre)	6.	50	24.	50	36 hr
Heavy Brush (40 tons/acre)	10.	40	70.	60	72 hr
Timber	24.	17	157.	83	7 days

Table 15-11 [redacted] Criteria of "No-Spread" of Fires [redacted]

Fuel Type	Criteria
All forest fuels	Over 1 inch of snow on the ground at the nearest weather stations.
Grass	Relative humidity above 80 percent.
Brush or hardwoods	0.1 inch of precipitation or more within the past 7 days and: Wind 0-3 mph; relative humidity 60 percent or higher, or Wind 4-10 mph; relative humidity 75 percent or higher, or Wind 11-25 mph; relative humidity 85 percent or higher.
Conifer timber	1. One day or less since at least 0.25 inch of precipitation and: Wind 0-3 mph; relative humidity 50 percent higher, or Wind 4-10 mph; relative humidity 75 percent higher, or Wind 11-25 mph; relative humidity 85 percent or higher. 2. Two to three days since at least 0.25 inch of precipitation and: Wind 0-3 mph; relative humidity 60 percent or higher, or Wind 4-10 mph; relative humidity 80 percent or higher, or Wind 11-25 mph; relative humidity 90 percent or higher. 3. Four to five days since at least 0.25 inch of precipitation and wind 0-3 mph; relative humidity 80 percent or higher. 4. Six to seven days since at least 0.25 inch of precipitation and wind 0-3 mph; relative humidity 90 percent or higher.

[redacted] shielding from the wind and shading from sunlight by the canopy. The spread or no-spread criteria are summarized in Table 15-11. This table lists the conditions under which fire would not be expected to spread.

[redacted] The criteria of Table 15-11 have been compared to the records of 4,378 wildland fires. Of the fires for which "no spread" would be predicted, 97.8 percent did not spread; only 40 percent of the fires that were predicted to spread actually did spread (at a rate of 0.005 mph or faster). This failure to spread often may be attributable to lack of fuel continuity around the point of origin.

[redacted] The criteria of Table 15-11 are considered to be reliable for American forests and suitably conservative to assure a low level of hazard to friendly forces. On the other hand, the criteria are probably not overly conservative to predict conditions for which enemy forces may be denied forested areas because of fire whenever the local weather history and conditions at the time of

[redacted] SURVIVAL IN FIRE AREAS [redacted]

[redacted] The best documented fire storm in history (but not the one causing the greatest loss of life) occurred in Hamburg, Germany during the night of July 27-28, 1943, as a result of an incendiary raid by Allied forces. Factors that contributed to the fire included the high fuel loading of the area and the large number of buildings ignited within a short period of time.

[redacted] The main raid lasted about 30 minutes. Since the air raid warning and the first high explosive bombs caused most people to seek shelter, few fires were extinguished during the attack. By the time the raid ended, roughly half the buildings in the 5 square-mile fire storm area were burning, many of them intensely. The fire storm developed rapidly and reached its peak in two or three hours.

[redacted] Many people were driven from their shelters and then found that nearly everything was burning. Some people escaped through the streets; others died in the attempt; others returned to their shelters and succumbed to carbon monoxide poisoning.

[redacted] Estimates of the number that were killed range from about 40,000 to 55,000. Most of the deaths resulted from the fire storm. Two equally heavy raids on the same city (one occurred two nights earlier; the other, one night later) did not produce fire storms, and they resulted in death rates that have been estimated to be nearly an order of magnitude lower.

[redacted] More surprising than the number killed is the number of survivors. The population of the fire storm area was roughly 280,000. Estimates have been made that about 45,000 were rescued, 53,000 survived in non-basement shelters, and 140,000 either survived in basement shelters or escaped by their own initiative.

9-25 Causes of Death [redacted]

[redacted] The evidence that can be reconstructed from such catastrophes as the Hamburg fire storm indicates that carbon monoxide and excessive heat are the most frequent causes of death in mass fires. Since the conditions that offer protection from these two hazards generally provide protection from other hazards as well, the following discussion is limited to these two causes of death.

[redacted] *Carbon Monoxide.* Burning consists of a series of physical and chemical reactions. For most common fuels, one of the last of the reactions is the burning of carbon monoxide to form carbon dioxide near the tips of the flames. If the supply of air is limited, as it is likely to be if the fire is in a closed room or at the bottom of a pile of debris from a collapsed building, the carbon monoxide will not burn completely. Fumes from the fire will contain a large amount of this tasteless, odorless, toxic gas.

[redacted] During the Hamburg fire, many basement shelters were exposed to fumes. Imperfectly fitting doors and cracks produced by exploding bombs allowed carbon monoxide to penetrate these shelters. The natural positions of many of the bodies recovered after the raid indicated that death had often come without warning, as is frequently the case for carbon monoxide poisoning.

[redacted] Carbon monoxide kills by forming a more stable compound with hemoglobin than either oxygen or carbon dioxide will form. These latter are the two substances that hemoglobin ordinarily carries through the blood stream. Carbon monoxide that is absorbed by the blood reduces the oxygen carrying capacity of the blood, and the victim dies from oxygen deficiency.

[redacted] As a result of the manner that carbon monoxide acts, it can contribute to the death of a person who leaves a contaminated shelter to attempt escape through the streets of a burning city. A person recovering from a moderate case of carbon monoxide poisoning may feel well while he is resting, but his blood may be unable

[redacted]

to supply the oxygen his body needs when he exerts himself. After the air raid at Hamburg, victims of carbon monoxide poisoning, apparently in good health, collapsed and died from the strain of walking away from a shelter. It is suspected that many of the people who died in the streets of Hamburg were suffering from incipient carbon monoxide poisoning.

[redacted] *Heat.* The body cools itself by perspiration. When the environment is so hot that this method fails, body temperature rises. Shortly thereafter, the rate of perspiration decreases rapidly, and, unless the victim finds immediate relief from the heat, he dies of heat exhaustion. Death from excessive heat may occur in an inadequately insulated shelter; it also may occur in the streets if a safe area cannot be located in a short time.

9-26 Shelters [redacted]

[redacted] The results of the Hamburg fire storm illustrate the value of shelters during an intense mass fire. The public air raid shelters in Hamburg had very heavy walls to resist large bombs. Reinforced concrete three feet thick represented typical walls. Some of these shelters were fitted with gas proof doors to provide protection from poison gas. These two features offered good protection from the heat and toxic gases generated by the fire storm.

[redacted] The public shelters were of three types:

- *Bunkers.* These were large buildings of several shapes and sizes, designed to withstand direct hits by large bombs. The fire storm area included 19 bunkers designed to hold a total of about 15,000 people. Probably twice this number occupied the bunkers during the fire storm, and all of these people survived.
- *Splinterproof Shelters.* These were long single story shelters standing free of other buildings and protected by walls of reinforced concrete at least 2-1/2 feet thick. No deaths resulting from the fire storm were reported among occupants of these shelters. These structures were not gas-proof. Distance from burning structures and low height of the shelters probably provided protection from carbon monoxide.
- *Basement Shelters.* The public shelters that were constructed in large basements had ceilings of reinforced concrete 2 to 5 feet thick. Although reports indicate that some of the occupants of these shelters survived and some did not, statistics to indicate the chance of survival in such structures are not available.
- *Private Basement Shelters.* Private basements were constructed solidly, but most of them lacked the insulating value of very thick walls and the protection of gas-tight construction. Emergency exits (usually leading to another shelter in an adjacent building) could be broken if collapse of the building caused the normal exit to be blocked. As a result of the total destruction in the fire storm area, this precaution was of limited value. Many deaths occurred in these shelters as a result of carbon monoxide poisoning, and the condition of the bodies indicated that intolerable heat followed the carbon monoxide frequently. In some cases, the heat preceded the poisonous gas and was the cause of death. Generally, these shelters offered such a small amount of protection that the occupants were forced out within 10 to 30 minutes. Most of these people were able to move through the streets and escape. Others were forced out later when the fire storm was nearer its peak intensity, and few of these escaped. A few people survived in private basement shelters.

November 1963
Second printing May 1964

Unclassified Version

SURVEY OF THE THERMAL THREAT OF NUCLEAR WEAPONS

Prepared for:

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF DEFENSE
WASHINGTON 25, D.C.

By: Jack C. Rogers and T. Miller

SRI Project No. IMU-4021

Approved:

Robert A. Harker

ROBERT A. HARKER, DIRECTOR
MANAGEMENT SCIENCES DIVISION

OCD REVIEW NOTICE

This report represents the authors' views, which in general are in harmony with the technical criteria of the Office of Civil Defense. However, a preliminary evaluation by OCD indicates the need for further evaluation of the fire threat of nuclear weapons and formulation of promising research and action programs.

NOTE: discrepancies are due to HUMIDITY differences.
ENCORE nuclear test (Nevada desert) humidity was ONLY 19%

Table B-VII

COMPARISON OF ESTIMATES FOR IGNITION ENERGY REQUIREMENTS
(10 mt)

Glasstone (1962) The Effects of Nuclear Weapons		Martin, et al. (1959) Naval Radiological Defense Laboratory		
Material	Cal/cm^2 for Ignition	Material	Cal/cm^2 for Ignition	Ratio of NRDL to ENW
Cotton auto seat upholstery, green, brown, white	16	Heavy cotton draperies, dark color	28	1.75
Wool pile chair upholstery, wine	35 (not sustained)	Wool pile chair upholstery, dark color	25	0.7
Newspaper, single sheet	6	Newspaper, medium printed	40	6.7
		Newspaper, dark areas	30	5.
Kraft paper carton, flat side exposed, used, brown	15	Corrugated Kraft board	40	2.6
Deciduous leaves	12	Walnut leaves	54	4.5
		Beech leaves	36	3.
Coarse grass	16	Harding grass	44	2.7
Ponderosa pine needles, brown	18	Pine needles	50	2.7

Sources: Martin, et al. (1959) and Glasstone (1962).

Martin, S. B., On Predicting the Ignition Susceptibility of Typical Kindling Fuels to Ignition by the Thermal Radiation from Nuclear Detonations, Tech. Report 367, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., April 1959. (U)

Weapon test report WT-775, Project 8.11b, ENCORE nuclear test, Nevada, 1953:

No trash kindling   Trash kindling for fire

Effect of 12 calories/sq cm thermal flash:

6' x 6' wood frame houses

CONFIDENTIAL

WT-774

Copy No. 186 A

Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

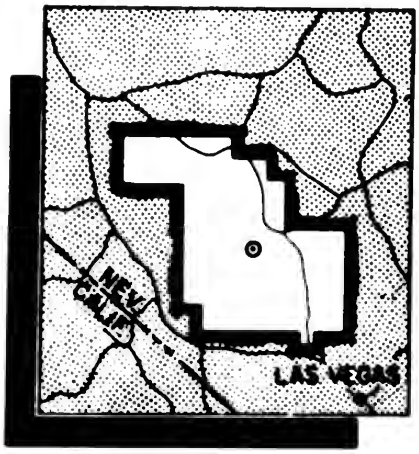
Project 8.11a

INCENDIARY EFFECTS ON BUILDING AND INTERIOR KINDLING FUELS

(ENCORE EFFECT REPORT)

27 kt at 2,423 feet altitude, 19% humidity

(DASA-1251) (Note: cities humidity is ~50-80%)



RESTRICTED DATA

This document contains restricted data as defined in the Atomic Energy Act of 1946. Its transmittal or the disclosure of its contents in any manner to an unauthorized person is prohibited.

HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

CONFIDENTIAL

Weapon test report WT-774, Project 8.11a, Incendiary effects on buildings and interior kindling fuels

ENCORE test, Nevada, 1953
10' x 12' wooden houses with 4' x 6' windows
17 calories/sq. cm thermal flash

Immediate room flashover during thermal pulse
("Encore effect") in inflammables-filled house
while fire-resistant fabrics in other house survived!

LEFT HOUSE: fire-resistant furnishings
(woolen rugs and clothes, vinyl plastic draperies)

RIGHT HOUSE: non-fire resistant furnishings
plus inflammable magazines and newspapers

Smouldering armchair extinguished 1 hour after detonation, when recovery party arrived at house

---

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We have all had the frustrating experience of trying to light a fire with green, moist, or wet wood. Just as wet wood can't be easily induced to burn, so thick combustibles are not easily ignited. Even a dry two-by-four burns reluctantly and stops burning when taken out of the fire. It is a different matter with a shingle or a bunch of kindling! Density also plays a role, a heavier combustible being harder to ignite than lighter-weight material. Of course, the chemistry of the material to the degree that it influences kindling temperatures and flammability, is an important parameter. Modern plastics tend to smoke and boil - to ablate but not to ignite in sustained burning - while paper trash burns readily.

Just as most materials are not particularly sensitive to the sun's thermal radiation, and are not highly inflammable nor even ignitible, the surfaces exposed to the thermal intensity of a nuclear explosion are generally not given to sustained burning. Very intense heat loads may mar or melt surfaces, may char and burn surfaces while the heat is on, but may snuff out immediately afterward.

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PRIMARY AND SECONDARY FIRES FROM NUCLEAR EXPLOSIONS

Although thermal radiation would start many fires in urban and in most suburban areas, such fires by themselves would seldom constitute a source of major destruction. Outside the region of extensive blast damage, fires in trash piles, in dry palm trunks, in roof shingles, in auto and household upholstery, drapes, or flammable stores are normally accessible and readily controllable. By the very fact that these fires start from material exposed to the incident light, they can be easily spotted and, in the absence of other distractions, can be quickly extinguished. Where the blast effects are severe and damage extensive, little effective fire fighting is likely.

cue for survival

OPERATION CUE

A.E.C. NEVADA TEST SITE

MAY 5, 1955

A report by the FEDERAL CIVIL DEFENSE ADMINISTRATION

EFFECTS OF NUCLEAR WEAPONS

BY HAROLD L. GOODWIN,
Director, Atomic Test Operations, FCDA

The time of travel of the shock wave is not generally understood by many persons. The concept of "duck and cover," which would still be of great value in case of attack without warning, is based on the comparatively large time interval between the burst and arrival of the shock wave at a given point.

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BIOMEDICAL EFFECTS OF THERMAL RADIATION

BY DR. HERMAN ELWYN PEARSE, *Professor of Surgery at the University of Rochester. Consultant to several Government departments, notably the Atomic Energy Commission's Division of Biology and Medicine. Consultant to the Armed Forces Special Weapons Project*

After the Bikini test, I was asked to go to Japan as a consultant for the National Research Council to survey the casualties in Nagasaki and Hiroshima.

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Then we observed the healing of the wounds, and we found again that the wounds healed in the same manner as those that we had produced in the laboratory. There was some difference in these lesions from the ordinary burns of civil life, but I would predict, from what I learned from experiments, that the difference is on the good side. The burns look worse; they are often charred, but they may not penetrate as deeply, and the char acts as a dressing, nature's own dressing.

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For example, if you have 2 layers, an undershirt and a shirt, you will get much less protection than if you have 4 layers; and if you get up to 6 layers, you have such great protection from thermal effects that you will be killed by some other thing. Under 6 layers we only got about 50 percent first degree burns at 107 calories.

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If we can just increase the protection a little bit, we may prevent thousands and thousands of burns.

... For example, to produce a 50-percent level of second-degree burns on bare skin required 4 calories. When we put 2 layers of cloth in contact, it only took 6 calories. But separate that cloth by 5 millimeters, about a fifth of an inch, and it increases the protective effect 5 times. The energy required to produce the same 50-percent probability of a second-degree burn is raised up to 30 calories. So if you wear loose clothing, you are better off than if your wear tight clothing.

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Abridged

THE BURN SURFACE AS A PARASITE

WATER LOSS, CALORIC DEMANDS, AND THERAPEUTIC IMPLICATIONS

Carl Jelenko, III, M.D.

Department of Surgery

University of Maryland School of Medicine and Hospital

Baltimore, Maryland

Water is Lost through Burned Skin

If, during the first 48 hours after injury, no more fluid is given to an extensively burned patient than he would need in health, the uncompensated loss of fluid from his circulation may cause shock, and if sufficiently severe, death.

Heat is Lost Necessitating a High Food Intake

To make matters worse, evaporation of moisture from the wound surface saps not only the body's water stores but its energy stores as well. When water evaporates from the burned surface, cooling results and the body loses heat. The larger the burn wound, the more water loss and the more heat or energy loss.

How Can the Fluid and Heat Losses Be Diminished?

Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP (American College of Emergency Physicians) News
http://www.acep.org/content.aspx?id=40462

August 2008
By Patrice Wendling
Elsevier Global Medical News

CHICAGO - Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit.

The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

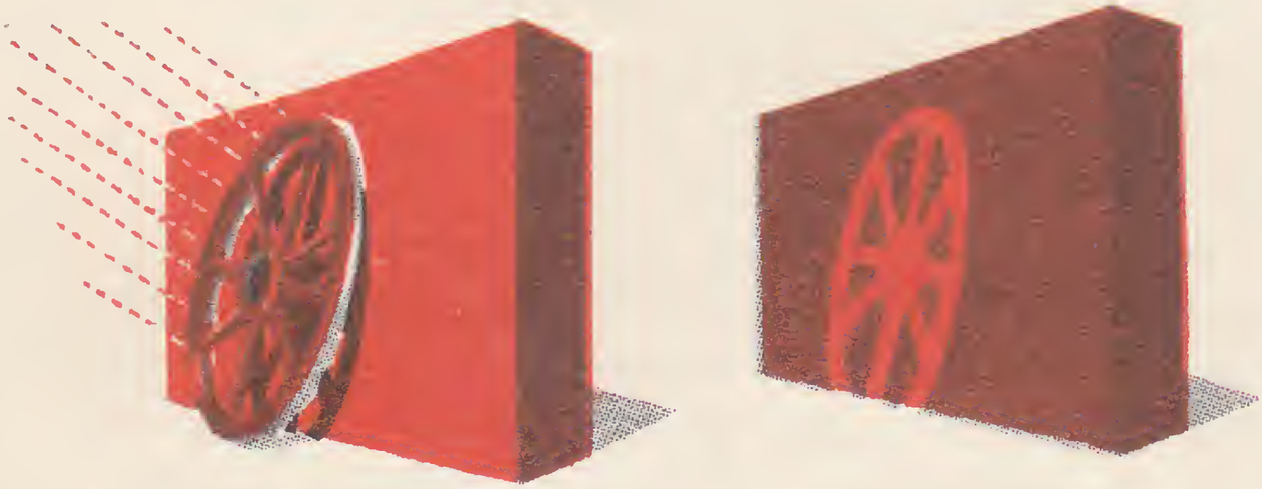
Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it's inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

The Hydrogen Bomb

HER MAJESTY'S STATIONERY OFFICE

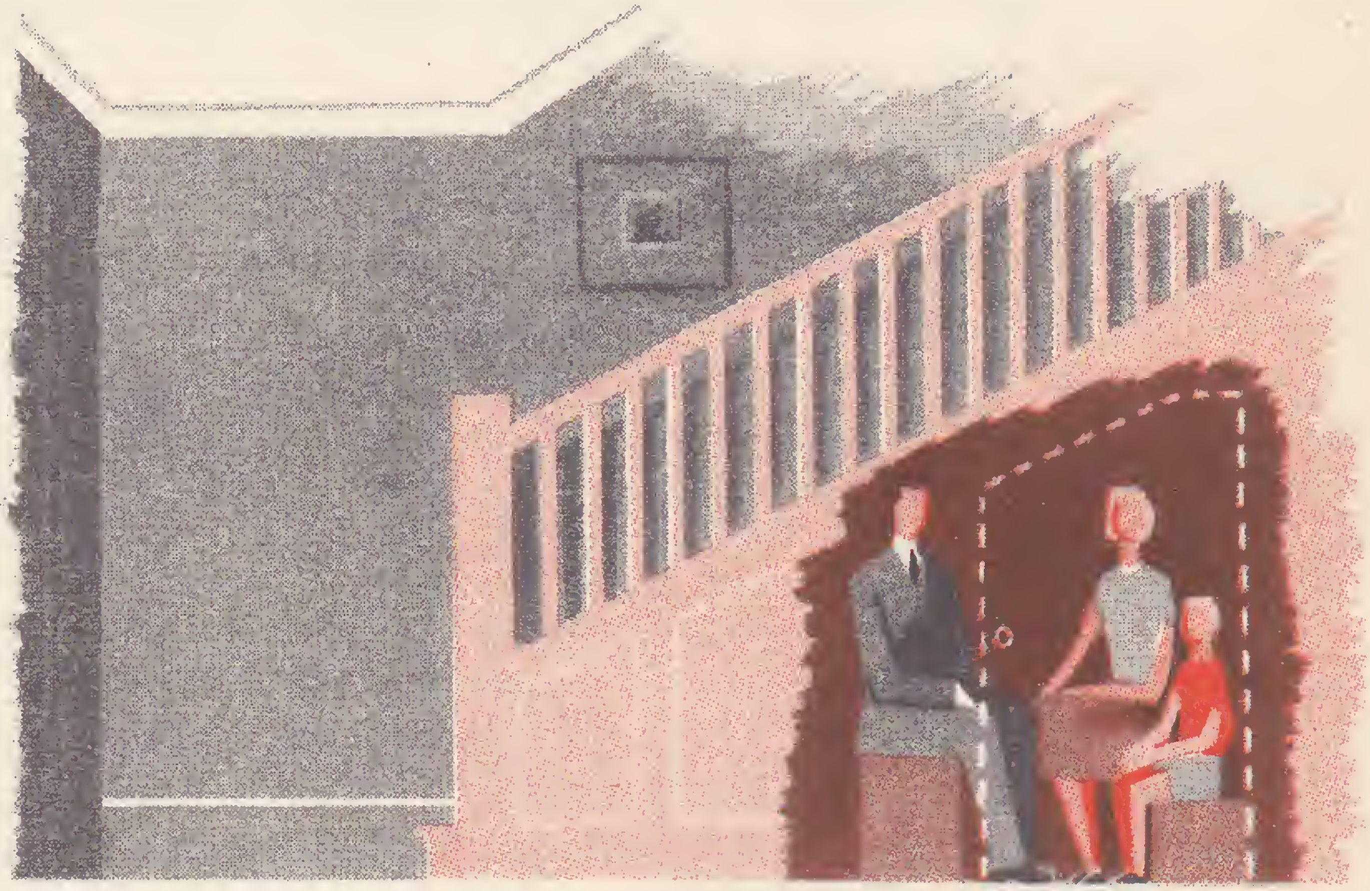
NINEPENCE NET

Anything that keeps off the sun's heat will help to give protection against the heat of a nuclear bomb. At Hiroshima, for instance, a painted surface was scorched except where it was in the shadow of a wheel.



The protection given by clothing depends on the distance from the explosion. The chances of escaping serious burns are increased by wearing hat and gloves and slacks or trousers. At Hiroshima some Japanese women, who had on white cotton dresses with a darker pattern, suffered burns only beneath the pattern. The skin under the white material escaped. This was because white or light-coloured material reflects heat while dark material absorbs it. Colour apart, woollen clothes would be less likely to catch fire than cotton. If clothing did catch fire and there was no time to throw it off, the best way to put out the flames would be to roll over and over on the ground.

All this applies only to people caught in the path of the heat rays. Any solid substance would give full protection against this danger, and a few minutes' warning of the attack would give people time to take cover. Even if they had not heard a warning, people at a distance who took cover even a few seconds after the explosion of a hydrogen bomb would escape some of the heat.



The stairs would give some protection against falling debris

Best at resisting pressure are heavily framed steel and reinforced concrete buildings or those with rounded streamlined surfaces. In Nagasaki, for instance, most of the tall factory chimneys survived.

THE DANGER TO PEOPLE

At Hiroshima and Nagasaki very few injuries, such as perforated ear-drums, were caused directly by the blast itself. The real danger is that people would be struck by falling masonry, flying debris or fragments of glass, or might themselves be thrown against some object.

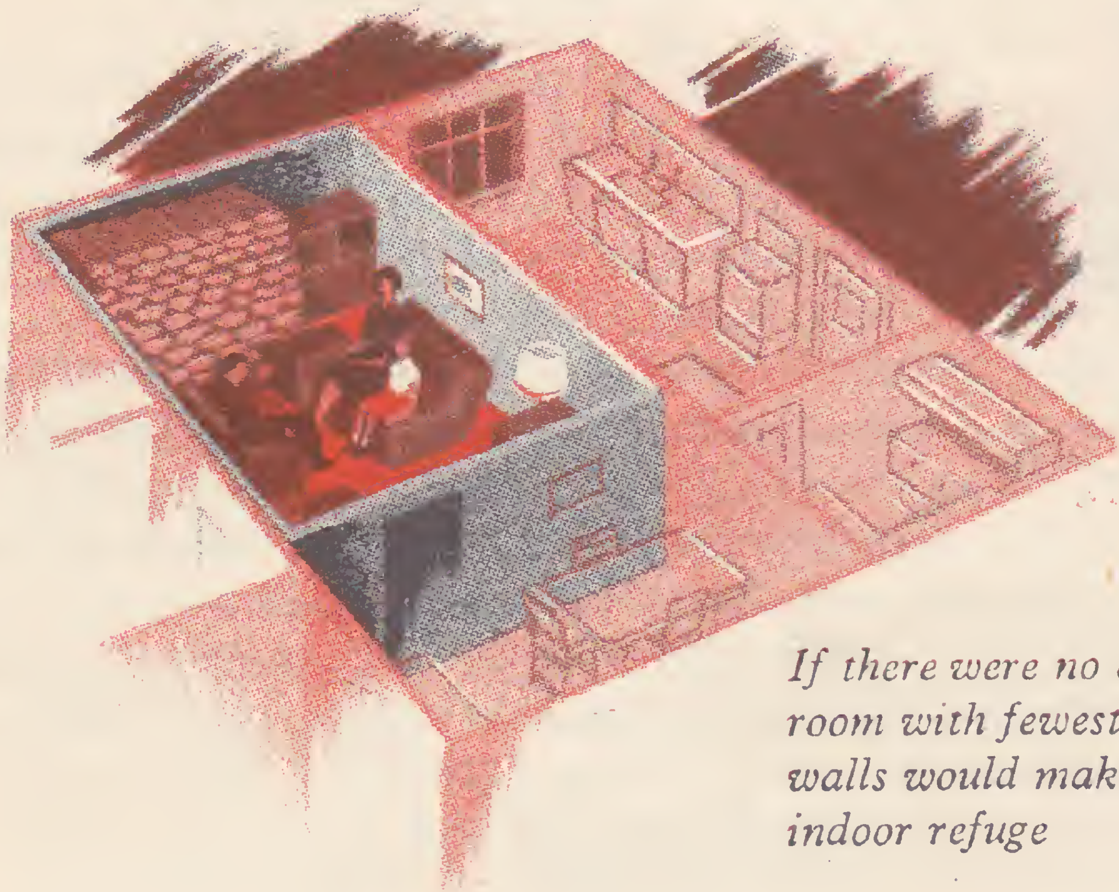
The warning system, however, is designed to enable people to get under cover. A slit trench, especially if covered with a

few feet of earth, or a cellar or basement would give good protection. If there were no cellar or basement it would be safest under the stairs, or under a table or bed which would give some protection should the roof or ceiling collapse; and if there were no time to reach such places before the flash is seen, the best place indoors would be close to an inside wall, avoiding windows or anywhere in the possible path of flying glass.

People caught unprotected in the open could at least try to shelter from the rubble and flying debris, if only in doorways or behind walls or even trees. Failing this, they could fall flat on the ground, with the head and face covered, if possible close to the wall of a substantial building, or in a nearby ditch or gutter.

A slit trench with earth covering protects against blast and radiation

A prepared refuge room inside a house could be made to give good protection against fall-out (although not so good as a covered slit trench) and it would also be much less uncomfortable for a period of two days or more. A cellar or basement would be by far the best place for a refuge room; next best would be the room with the fewest outside walls and the smallest windows. The windows would need to be blocked with solid material, to the thickness of the surrounding walls at least. It would help if the walls themselves were thickened, not necessarily to their full height, with sandbags, boxes filled with earth, or heavy furniture. The occupants of the refuge room would have to remain in it until told that it was safe to come out—perhaps for a period of days—and the room would have to be prepared and equipped accordingly.



If there were no cellar, the room with fewest outside walls would make the best indoor refuge

In some places it might be practicable to make good use of both an outdoor slit trench and an indoor refuge room, using the first for protection against blast, and the second, if the house survived the blast, for subsequent protection against fall-out.

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~~TOP SECRET~~

A-38/

DEPARTMENT OF DEFENSE

POLICY GUIDANCE FOR THE EMPLOYMENT OF NUCLEAR WEAPONS (NUWEP) (U)

OCTOBER 1980

22 DOD / DFOISR
TOP SECRET CONTROL
Copy No.
Case No. 98-F-1838
T.S. No. 98-TS-101
Document No. 1

OFFICE OF THE SECRETARY OF DEFENSE
THE PENTAGON
WASHINGTON, D.C. 20301

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(24 C-7-83)

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SEC DEF CONT Nr. X-11328

IV. STRATEGY FOR EMPLOYMENT

A. Flexibility

(U) The U.S. must have the capability to respond appropriately and effectively to any level of Soviet aggression, over the continuum of nuclear weapon employment options, ranging from use of a small number of strategic and/or theater nuclear capable weapon systems in a contingency operation, to a war employing all elements of our nuclear forces in attacks against a broad spectrum of enemy targets. The ability to respond with selectivity to less than an all-out Soviet attack in keeping with the needs of the situation is required in order to provide the National Command Authorities (NCA) with suitable alternatives, strengthen deterrence, and enhance the prospects of limiting escalation of the conflict. In addition to pre-planned options we need an ability to design employment plans on short notice in response to the latest and changing circumstances. To advance the goal of flexibility, planning will provide an objective-oriented series of building block options for the employment of nuclear weapons in ways that will enable us to employ them consonant with our objectives and the course of the conflict.

~~(C)~~ As it evolves, the building block approach should provide plans which satisfy a hierarchy of targeting objectives and which will provide the NCA an improved capability to employ nuclear weapons effectively in as measured and controlled a manner as feasible in case of a limited conflict. It should provide complementary elements which can be combined in an integrated and discrete manner to provide larger and more comprehensive plans for achieving politico-military objectives in specific situations. The building block approach places emphasis on the individual elements, their objective utility, and our ability to employ them separately or in total. However, this does not imply that the total plan be finely divisible--practical realities cannot be ignored. The desire for enhanced flexibility in employment must be balanced by practical consideration of the increased complexity incurred in planning and operations, the need to avoid compromising the effectiveness and workability of the larger options, and the need to maintain a responsive decisionmaking and force execution process.

THE WHITE HOUSE

WASHINGTON

#76

~~TOP SECRET/SENSITIVE~~

July 25, 1980

Presidential Directive/NSC-59

TO: The Vice President
The Secretary of Defense

ALSO: The Assistant to the President for National Security Affairs
The Chairman, Joint Chiefs of Staff

SUBJECT: Nuclear Weapons Employment Policy (C)

In PD-18, I directed a follow-on study of our targeting policy for nuclear forces. I have reviewed the results and considered their implications for maintaining deterrence in the present decade, particularly in light of the growing Soviet strategic weapons arsenal and its capabilities. (S)

The most fundamental objective of our strategic policy remains nuclear deterrence. I reaffirm the directive of PD-18 to that effect. The purpose of this directive is to outline policies and actions in the nuclear force employment field to secure that continuing objective. (S)

Our strategic nuclear forces must be able to deter nuclear attacks not only on our own country but also on our forces overseas, as well as on our friends and allies, and to contribute to deterrence of non-nuclear attacks. To continue to deter in an era of strategic nuclear equivalence, it is necessary to have nuclear (as well as conventional) forces such that in considering aggression against our interests any adversary would recognize that no plausible outcome would represent a victory on any plausible definition of victory. To this end and so as to preserve the possibility of bargaining effectively to terminate the war on acceptable terms that are as favorable as practical, if deterrence fails initially, we must be capable of fighting successfully so that the adversary would not achieve his war aims and would suffer costs that are unacceptable, or in any event greater than his gains, from having initiated an attack. (C)

~~TOP SECRET/SENSITIVE~~
Review on May 15, 2000
Reason for Extension: NSC 1.13(e)

The employment of nuclear forces must be effectively related to operations of our general purpose forces. Our doctrines for the use of forces in nuclear conflict must insure that we can pursue specific policy objectives selected by the National Command Authorities at that time, from general guidelines established in advance. (S)

These requirements form the broad outline of our evolving countervailing strategy. To meet these requirements, improvements should be made to our forces, their supporting C3 and intelligence, and their employment plans and planning apparatus, to achieve a high degree of flexibility, enduring survivability, and adequate performance in the face of enemy actions. The following principles and goals should guide your efforts in making these improvements. (S)

<u>Pre-planned options</u>. The Single Integrated Operational Plan will provide pre-planned targeting for strikes against the Soviet Union, its allies and its forces. It should provide for retaliatory strikes that will be effective, even if the Soviets attack first, without warning, and in a manner designed to reduce our capability as much as possible. It will be developed with flexible sub-options that will permit, to the extent that survival of C3 allows, sequential selection of attacks from among a full range of military targets, indistrial targets providing immediate military support, and political control targets, while retaining a survivable and enduring capability that is sufficient to attack a broader set of urban and industrial targets. In addition, to the maximum extent possible, pre-planned options will be provided for selection in response to specific, lesser contingencies (including attacks on Cuba, SRV and North Korea as appropriate). [redacted]

While it will remain our policy not to rely on launching nuclear weapons on warning that an attack has begun, appropriate pre-planning, especially for ICBMs that are vulnerable to a preemptive attack, will be undertaken to provide the President the option of so launching. (TS)

<u>Flexibility</u>. In addition to pre-planned options we need an ability to design nuclear employment plans on short notice in response to the latest and changing circumstances. This capability must be comprehensive enough to allow rapid construction of plans that integrate strategic force employment with theater nuclear force employment and general purpose force employment for achieving theater campaign objectives and other national objectives when pre-planned response options are not judged suitable in the circumstances. (S)

To assure that we can design such plans, our goal should be to have the following capabilities on a continuing basis in peacetime, during crises, and during protracted conflict:

-- Staff capabilities, within all unified and specified commands which have nuclear forces, to develop operational plans on short notice and based on the latest intelligence.

-- Staff capabilities at the seat of Government to support the NCA for coordinating and integrating the nuclear force employment for all commands.

-- Intelligence and target development capabilities which permit damage assessment and acquisition of a broad range of targets, fixed and mobile, on a timely basis for military operations. (S)

Reserve Forces. Pre-planned options should be capable of execution while leaving a substantial force in secure reserve and capable of being withheld for possible subsequent use. The forces designated for the reserve should be the most survivable and enduring strategic systems consistent with the need for a flexible and varied reserve force capable of being effectively employed against a wide target spectrum and withheld if necessary for a prolonged period. The secure reserve force will be increased over the next two years to support a more flexible execution of our countervailing strategy. This will be done according to the Secretary of Defense's guidance. (TS)

Targeting categories. Overall targeting planning appropriate to implement a countervailing strategy will result in a capability to choose to put the major weight of the initial response on military and control targets. Military targets must be selected for the purpose of destroying enemy forces or their ability to carry out military operations. Strategic and theater nuclear forces should to the extent feasible be used in combination with, and in support of, general purpose forces to achieve that objective. (S)

More specifically, the following categories of military targets, with appropriate sub-options for different theaters, should be covered in planning:

-- strategic and theater nuclear forces, including nuclear weapons storage;

-- military command, control, communications, and intelligence capabilities;

-- all other military forces, stationary and mobile;

-- industrial facilities which provide immediate support to military operations during wartime. (TS)

In addition, pre-planned options, capable of relatively prolonged withhold or of prompt execution, should be provided for attacks on the political control system and on general industrial capacity. (TS)

There must be extensive and effective coverage in the pre-planned options of all categories. Methods of attack on particular targets should be chosen to limit collateral damage to urban areas, general

industry and population targets outside these categories, consistent with effectively covering the objective target, and, where appropriate, overall plans should include the option of withholds to limit such collateral damage. (TS)

Command, Control and Communications, and Intelligence. Flexibility in contingency planning and in operations will be highly dependent on our C^3I capabilities, including their ability to acquire targets, assess damage, and survive attack. Strategic stability in an era of essential equivalence depends as much on survivability, endurance and reconstitutability of C^3I capabilities as it does on the size and character of strategic arsenals. (C)

PD/NSC-53 directs that our C^3I programs and our guidance to telecommunications common carriers support the development and maintenance of such capabilities. In addition, PD/NSC-41 directs that we seek greater continuity of government should deterrence fail. Implementation of PD/NSC-53 and PD/NSC-41 must be pursued in parallel with that of this employment directive. (C)

The relationship of acquisition policy to employment policy. Our acquisition programs must be evaluated in terms of their support for the employment policy ordered by this directive. The required flexibility, survivability, endurance, and target destruction capability must be taken into account in developing programs for acquiring nuclear weapons systems, and their supporting C^3I systems, needed to support our countervailing strategy. (S)

Implementation. As new targeting capabilities are developed, and as our operational staffing support change to meet the foregoing directives, they must be reviewed and tested to validate their feasibility and soundness. For that purpose:

-- At least two exercises involving the National Command Authorities should be conducted each year to evaluate our capabilities and our employment doctrines.

-- Continued study and analysis of means to improve and refine our countervailing strategy of general conflict should be conducted by the Department of Defense.

-- The results of these exercises, studies and analysis will provide the bases for modification and any further development of employment and acquisition policy.

-- A report will be rendered to the President at least annually on our employment plans, including, but not limited to, on the size and capability of the reserve forces, the degree of flexibility available,

limiting factors in achieving flexibility, and the status of programs to provide improvements.

-- Any change or new pre-planned options will be submitted to the President for his review and approval, in accordance with current procedures. (TS)

NSDM-242 is superseded by this directive. (U)

Jimmy Carter

NUCLEAR WAR STRATEGY

(Concerning President Carter's 25 July 1980 Presidential Directive PD-59, "Nuclear Weapons Employment Policy")

HEARING

BEFORE THE

COMMITTEE ON FOREIGN RELATIONS
UNITED STATES SENATE

NINETY-SIXTH CONGRESS

SECOND SESSION

ON

PRESIDENTIAL DIRECTIVE 59

SEPTEMBER 16, 1980

(TOP SECRET HEARING HELD ON SEPTEMBER 16, 1980; SANITIZED AND PRINTED ON FEBRUARY 18, 1981)

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APPENDIX

Administration's Responses to Questions Submitted Before the Hearing

Question 1. What are the basic strategic targeting priorities in PD–59? How do these differ from previous targeting guidance, particularly that contained in NSDM 242?

Answer. PD–59 specifies the development of plans to attack a comprehensive Soviet/Warsaw Pact target system, with the flexibility to employ these plans, should deterrence fail, in a deliberate manner consistent with the needs of the situation and in a way which will deny an aggressor any gain, or would impose costs which clearly exceed his expected gains. This could entail initial retaliation on military and control targets while retaining the capability either to withhold for a relatively prolonged period, or to execute, broad retaliatory attacks on the political control system and on general industrial capacity. These individual target systems, which we feel the Soviet leaders value most, include leadership and control, military forces both nuclear and conventional and the industrial/economic base. Highlights of targeting aspects include an increased number of situation-oriented options, and more flexibility for selectively attacking all categories of targets.

PD–59 requires the option to attack a full range of industrial/economic targets be retained. PD–59 also places more emphasis on how to improve the effectiveness of targeting retaliation against Warsaw Pact leadership and control, nuclear forces, and conventional forces in a wartime situation. In contrast to some pronouncements by the press, the United States has never had a doctrine based simply and solely on reflexive, massive attacks on Soviet cities. Instead, we have always planned both more selectively (options limiting industrial/economic damage) and more comprehensively (a range of military targets in addition to the industrial/economic base). Previous Administrations, going back well into the 1960s, recognized the inadequacy of a strategic doctrine that would give us too narrow a range of options. The fundamental premises of our countervailing strategy are a natural evolution of the conceptual foundations built over the course of a generation. PD–59 is not a new strategic doctrine; it is not a radical departure from past U.S. strategic policy. Our countervailing strategy, as formally stated in PD–59, is in fact, a refinement, a codification of previous statements of our strategic policy. PD–59 takes the same essential strategic doctrine, and restates it more clearly, more cogently, in the light of current conditions and current capabilities.

Question 2. What are the fundamental political and military objectives for strategic targeting in PD–59? Is it envisaged that the United States could, under certain circumstances, conduct limited nuclear war for foreign policy, political or military objectives? Does the PD–59 envision the possibility of U.S. nuclear retaliation for any provocation short of a nuclear attack on the United States or its allies?

Answer. Deterrence remains, as it has been historically, our fundamental strategic objective. The overriding objective of our strategic forces is to deter nuclear war. But deterrence must restrain an adversary from carrying out any of a far wider range of threats than just that of massive attacks of U.S. cities. We seek to deter any adversary from any course of action that could lead to general nuclear war. Our strategic forces also must deter nuclear attacks on smaller sets of targets in the United States or on U.S. military forces overseas, and deter the nuclear coercion of, or attack on, our friends and allies. Our strategic forces, in conjunction with theater conventional and nuclear forces, must also contribute to deterrence of conventional aggression as well. I say "contribute" because we recognize that neither nuclear forces nor the cleverest theory for their employment can eliminate the need for us—and our allies—to provide a capable conventional deterrent.

In our analysis and planning, we are necessarily giving greater attention to how a nuclear war would actually be fought by both sides if deterrence fails. There is no contradiction between this focus on how a war would be fought and what its results would be, and our purpose of insuring continued peace through deterrence. Nor is there a contradiction between this focus and a judgment that escalation of a "limited" to an "all-out" nuclear war is likely. Indeed, this focus helps us achieve deterrence and peace, by insuring that our ability to retaliate is fully credible. We must have forces, contingency plans, and command and control capabilities that will convince the Soviet leadership that no war and no course of aggression by them that led to use of nuclear weapons—on any scale of attack and at any stage of conflict—could lead to victory, however they may define victory.

Operationally, our countervailing strategy requires that our plans and capabilities be structured to put more stress on being able to employ strategic nuclear forces selectively, as well as by all-out retaliation in response to massive attacks on the United States. It is our policy—and we have increasingly the means and the detailed plans to carry out this policy—to ensure that the Soviet leadership knows that if they chose some intermediate level of aggression, we could, by selective, large (but still less than maximum) nuclear attacks, exact an unacceptably high price in the things the Soviet leaders appear to value most—their military forces both nuclear and conventional, their political and military control apparatus, and the industrial capability to sustain a war. In our planning we have not ignored the problem of ending the war, nor would we ignore it in the event of a war. And, of course, we have, and we will keep, a survivable and enduring capability to attack the full range of targets, including the Soviet economic base, if that is the appropriate response to a Soviet strike.

The United States already retains the option of using weapons in a limited way in response to a conventional attack on us or our allies if necessary. However, PD–59 does *not* propose a first strike strategy. We are talking about what we could and (depending on the nature of a Soviet attack) would do in response to a Soviet attack. Nothing in the policy contemplates that nuclear war can be a deliberate instrument of achieving our national security goals because it cannot be. But we cannot afford the risk that the Soviet leadership might entertain the illusion that nuclear war could be an option—or its threat a means of coercion—for them.

Question 3. What alternative targeting strategies were examined in the studies which preceded PD–59? On what grounds were such alternatives rejected? Was the President presented with alternatives to the targeting policy set forth inPD–59?

Answer. Alternative targeting strategies were addressed. The alternative strategies examined were: (a) strengthen existing policy; (b) focus more heavily on denying Soviets a favorable war outcome; (c) add higher confidence capability against some target systems; and (d) rely more heavily on assured destruction.

Under alternative (a) the forces and related C^3I to accomplish this strategy would be given added endurance.

Alternative (b) placed more emphasis on targeting of Soviet (and non Soviet Warsaw Pact) nuclear and conventional forces to assure that they could not expect to achieve a favorable outcome or a victory, however victory might be defined, while retaining an assured destruction capability.

Alternative (c) would require greater capabilities against certain Soviet forces than in alternative (b).

The last alternative, (d), also would avoid the need to make any improvements to the flexibility and endurance of strategic forces and C^3I.

Each of the alternatives was considered in light of: (a) what flexibility in our nuclear posture (i.e., how broad a range of options) is desired; (b) how much endurance do our forces and C^3I require; (c) how much capability is considered necessary; (d) costs of achieving these capabilities.

These considerations were weighed against the ability of each of the alternatives to deter the Soviets, taking into account Soviet attitudes toward concepts of nuclear war and perceptions of our capabilities and will, as well as the perceptions of our friends and allies. In the final analysis, a policy was selected which was judged to be most realistic considering the current relationship between the U.S. and the U.S.S.R., and the world situation, and considering the continued aggressive pursuit by the Soviets of comprehensive improvement in all aspects of military force capabilities, both nuclear and conventional.

A belief in the continuing utility of war as a policy instrument and the need for military superiority fit well into Soviet discussions of victory in a global conflict. It should be noted that Soviet civilian leadership has made statements as to the destructiveness of nuclear war and the need for U.S.-U.S.S.R. arms control measures. At the same time, it is appropriate to take note of high level Soviet statements which tend to point to a somewhat different direction. For instance, the Chief of the Soviet Strategic Missile Forces has observed that:

> The imperialist ideologists are trying to lull the vigilance of the world's people by having recourse to propoganda devices to the effect that there will be no victors in a future nuclear war. These false affirmations contradict the objective laws of history . . . Victory in war, if the imperialists succeed in starting it, will be on the side of world socialism and all progressive mankind. (Marshal of the Soviet Union N. I. Krylov, "The Instructive Lessons of History", *Sovetskaia Rossiia*, August 30, 1969, UNCLASSIFIED).

President (and Marshal of the Soviet Union) Brezhnev is also on record as saying that:

> Let it be known to all that in a clash with any aggressor the Soviet Union will win a victory worthy of our great people, of the homeland of the October Revolution. (L. I. Brezhnev, Speech on the 50th Anniversary of the October Revolution, *Pravda*, November 4, 1967, UNCLASSIFIED).

In addition to such doctrinal presentations, the Soviet leaders make evident through their programs their concerns about the failure of deterrence as well as its maintenance, and their rejection of such concepts as minimum deterrence and assured destruction as all-purpose strategic theories. As Secretary Brown has indicated, what is most troublesome is the heavy emphasis in Soviet military doctrine on the acquisition of war-winning (whatever the duration of the conflict) capabilities, and the coincidence (in one sense or another of the word) between their programs and what have been alleged as the requirements of a deliberate war-winning strategy. This compilation of Soviet sources—which could be added to almost indefinitely—is sufficient to demonstrate that the Ogarkov quotation used in the speech quoted in the question was not an aberration. There are, to be sure, quotations to be found that indicate different views—partly because there are no doubt different views within the Soviet system, more often because they are addressed to different audiences. There is no question that the Soviet leadership understands that nuclear war would be immensely destructive and uncertain; it is to re-inforce that perception—and to add to it the conclusion, found only very infrequently if at all in public statements, that the U.S.S.R. could not fight and win such a war—that the countervailing strategy is directed.

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EXPLODING THREE MILE ISLAND.

Think back. It hasn't been that long ago.

Pennsylvania looked like it might be blown off the map any minute, turned into a radioactive no-man's-land forever. "Permanently uninhabitable" was the way they said it in the movie, *The China Syndrome.*

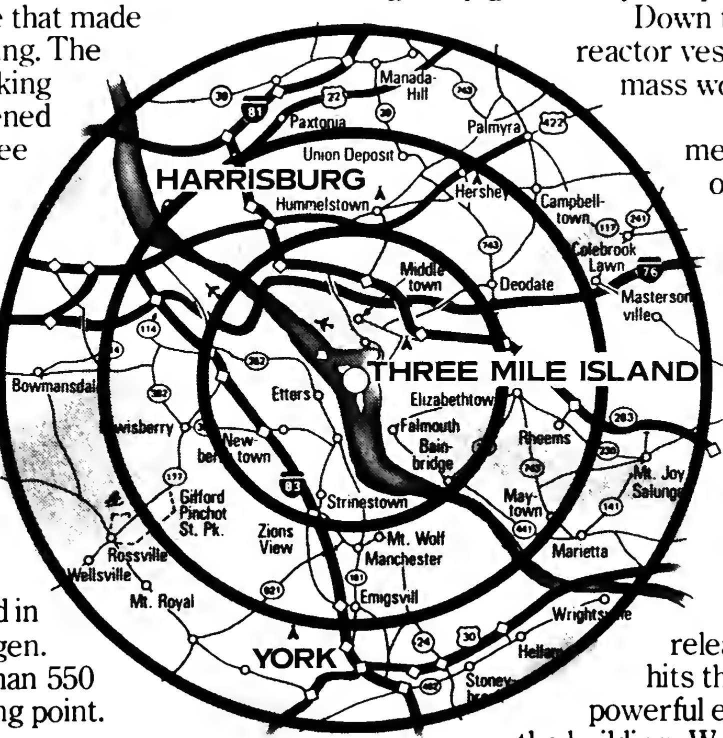
That's the trouble. A lot of people said a lot of things. And a lot of it just wasn't true. Not even close.

Take the hydrogen bubble that made all the headlines. Bubble, nothing. The implication was time bomb, ticking away. And that would've frightened anybody who didn't have a degree in chemistry.

The fact is, that bubble couldn't explode. Not by any stretch of the imagination.

To understand why, you have to understand how the hydrogen got there in the first place. And that takes some understanding of how the reactor at Three Mile Island was designed to work.

It's the pressurized-water type, meaning the fuel core was cooled by keeping it submerged in water. H_2O. Hydrogen and oxygen. Heated by the core to more than 550 degrees, well beyond the boiling point.



What kept it from boiling was pressure, approximately 2,000 pounds worth. But on March 28th, last year, a relief valve on the pressurizer stuck open, the pressure dropped, and the water—the H_2O—inside the reactor boiled into steam.

When that happened, the zirconium-alloy tubes housing the fuel underwent a chemical reaction. A kind of accelerated rusting that combined the zirconium from the tubes with oxygen from the water to form zirconium oxide.

That's important, because with all the oxygen used up by the chemical reaction, the only part of the water left was hydrogen. The bubble. And what nobody bothered to tell you at the time was that without oxygen, hydrogen can't explode.

On May 1st, more than a month later, the Nuclear Regulatory Commission admitted the scare was all a mistake. Roger Mattson, Director of its Systems Safety Division, told a congressional committee there "never was any danger of a hydrogen explosion in that bubble."

That never made headlines.

And more than likely, neither will the fact that even if there had been a meltdown, it wouldn't have spelled disaster for Pennsylvania. It couldn't have.

First of all, the fuel core in the reactor vessel was surrounded by a containment building. Not just any building, an immense fortress with an enormously thick floor. Eleven feet of solid concrete reinforced with steel.

Second, for a molten mass to eat through it, that concrete-and-steel floor couldn't be covered with water. But water is what's used to cool the core. And when the relief valve on the pressurizer stuck open, sending several hundred thousand gallons shooting out, the law of gravity gave it only one place to go.

Down to the floor, right under the reactor vessel. Right in the path a molten mass would take.

That's the fallacy of the meltdown theory. In spite of the overwhelming odds against it, if all systems failed, if the entire core melted, if it got through the foot-thick steel reactor vessel in one piece and dropped to the floor below, it would've been stopped right there. Cooled by an ocean of water inside the containment building, not 20 feet from where the meltdown started.

As for any sudden burst of steam pressure that might be released when the molten mass hits the water, it wouldn't be nearly powerful enough to rupture the walls of the building. Walls capable of withstanding almost twice as much force.

In other words, there was no way for significant radioactivity to reach the atmosphere outside.

The point of it all is that Three Mile Island and nuclear power itself deserve a fairer shake. A second look minus the hysteria, the hyperbole, the half-truths, and the untruths. They deserve a close, careful reading of the facts.

True, we've experienced the worst accident in the 22 years America has been using nuclear energy to produce electricity. But it wasn't the apocalypse. No one died. And except for the stress of being scared stiff, no one was injured. Despite the equipment failures and failures in judgment, despite everything that went wrong, the safety systems worked.

What really exploded were myths.

Commonwealth Edison

One in a series of ads on the issue of energy in our community, paid for by the company and not published at our customers' expense.